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# The American Journal of Surgery

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A PRACTICAL JOURNAL BUILT ON MERIT

## EDITORIAL

### OUR COATS ARE OFF

AS this is being written the world is topsy-turvy. The Allies have evacuated successfully their troops from Flanders—a historical military feat under the circumstances. Italy is expected to declare war any minute.\* The Germans have closed in on Paris. What Turkey will do is conjectural. The President has asked for and has been voted about \$5,000,000,000 for defense. He has asked permission to call out the National Guard. A United States cruiser is on its way (a good will gesture) to Uruguay. Things are moving fast; everyone senses a great ground-swell of indignation against bandit countries, and the conviction obtains that we must prepare, that we must get so tough we will be respected and feared no matter what the cost. All of this no doubt will be old news when you read it. Less than two months ago the Germans invaded Norway and now it seems so long ago, so far in the distant past.

In H. I. Phillips' column in *The Sun* (New York) on May 31st, was the heading, "What America Needs Besides 50,000 Planes." This columnist has listed various moral characteristics that should permeate each citizen, while the nation is strengthening itself for the defense and well-being of those citizens. We quote in part:

\*They did on June 10, 1940.

"A realization that expediency, craftiness, artful dodging, compromise, an eager eye for the main chance and the spirit of every-man-for-himself have played too great a part in American life.

"Some appreciation of the fact that liberty is more than a word in a song, a reference in a newsreel or a free-wheeling device perpetuated by radio speeches and an ability to memorize the first two lines of the national anthem.

"A little more respect for the ancient truths, the lessons of history and the word of God.

"A realization by all hands that man owes a lot more to his country than his country owes to him.

"A return to the old-time standards of character that make it easy for a man to become indignant over corruption, come to a boil over injustice and get fighting over a wrong.

"Elimination of 'gimme-gimme' as the two most important words in English.

"A return to the faith of our fathers, to the teachings of Holy Writ and the impulse in all crises to turn to God in humility instead of to politicians in panic.

"A realization that when your country is in danger, and part of your job is helping to meet it, the main question shouldn't be 'How much do I get—and will the hours be short?'

"Some appreciation of the fact that in a grave crisis involving the nation in war, it is not unethical, unconstitutional or bad social practice to sweat on the job."

Many of us can take the above to heart.

The medical profession will do its part in these trying times. It is proud and envious of its past deeds and record and will repeat those sacrifices for the nation's good. It will

put aside until calmer and more peaceful times its minor economic problems; it will take off its coat and pitch in and work and sweat; and it will give of its knowledge and skill to the nth degree without quibbling or questioning. Physicians with few exceptions love, and stand ready to do and give without stint to their country—the United States.

T. S. W.



### DR. FRED S. ALBEE DOUBLY HONORED

The American Journal of Surgery wishes to express its felicitations to Dr. Fred S. Albee, a well-known orthopedic surgeon, for the double honor conferred upon him.

At the recent meeting of the International College of Surgeons, Dr. Albee was elected president for the ensuing year. This organization was founded in Geneva, Switzerland, and is composed of eminent surgeons the world over.

In addition, Rutgers University bestowed upon Dr. Albee the Honorary Degree of Doctor of Science in recognition of the pioneer work which he has done in the fields of bone surgery and rehabilitation, and as a tribute to him for twenty-one years of service as chairman of the Rehabilitation Commission in developing this service for the physically handicapped and crippled in the State of New Jersey.

T. S. W.

# ORIGINAL ARTICLES

## TUBAL PREGNANCY\*†

A STUDY OF CASES WITH EMPHASIS ON DIAGNOSIS AND ON BLOOD LOSS IN  
RELATION TO SHOCK SYMPTOMS

KEITH W. WOODHOUSE, M.D.

CEDAR RAPIDS, IOWA

THIS study of tubal pregnancy has been undertaken with several objectives: To correlate the various ideas on etiology and pathology as expressed by different writers on the subject; further to clarify diagnosis of this condition so aptly referred to by Dannreuther<sup>1</sup> as an "enigma"; and to analyze the clinical evidence of shock in relation to blood loss in order to determine whether hemorrhage alone is responsible for the distressing shock picture characterizing the more tragic cases of tubal pregnancy. Recent available American literature has been reviewed and a careful analysis of seventy-three consecutive cases of tubal pregnancy seen and operated at the Guthrie Clinic and Robert Packer Hospital between June 30, 1927 and April 30, 1938, has been made.

### EARLY HISTORY

There is no evidence that ectopic pregnancy was known as such to the ancient Greeks or Romans. Albucasis, an Arabian about the year 1050 A.D. described a condition which was apparently an extra-uterine pregnancy. This was the first recorded case.

Scheffey, Morgan and Stimson,<sup>2</sup> in an interesting article on ectopic pregnancy, stated that in 1851 Charles D. Meigs, then Professor of Midwifery and Diseases of Women and Children in Jefferson Medical College, described with great accuracy the

clinical picture in a series of cases of ruptured ectopic pregnancy, but went on to say: "What, alas, can we do in these cases? We could make an incision in the abdomen and clear away the coagula and the serum; but who is he bold enough to do so? . . . Nothing remains for us but to extend all the relief within the narrow boundaries of our power and calmly await and submit to the inevitable end." In view of our present conception of this condition, it is not surprising that the mortality at this period under palliative treatment was variously reported as 77.2 per cent in Parry's series of 500 cases in 1876, to 86.6 per cent reported on 121 cases by Schauta. The surgical treatment of ectopic pregnancy was initiated by the first operation for the condition described by Dr. John Bard of New York, December 25, 1859 and established twenty-four years later by Lawson Tait, who, in 1883, reported a series of forty cases treated surgically with but one death.

### INCIDENCE

The incidence of ectopic pregnancy is difficult to establish for a number of reasons. Births, but not abortions or ectopics, are recorded by the United States Census Bureau. The condition is one which is handled by obstetricians, gynecologists and general surgeons alike, and therefore not all cases fall in the records of one depart-

\* Thesis submitted to the Faculty of Surgery of the Graduate School of Medicine, University of Pennsylvania in partial fulfillment of the requirements for the degree of M. Sc. (Med.) for graduate work in surgery.

† Cases from Guthrie Clinic and Robert Packer Hospital, Sayre, Pennsylvania.

ment. Hospital incidence varies according to the location and type of the hospital whether in an urban or a rural locality and whether general or strictly gynecologic. Von Graff and Brown<sup>3</sup> felt it was safe to say that more than 10,000 cases occur annually in this country. The hospital incidence has been variously computed. Urdan<sup>4</sup> reported 1.5 per cent incidence in gynecological department cases at Mt. Sinai Hospital, New York. Koster and Sheinfeld<sup>5</sup> computed an incidence of slightly over 1 per cent of 6,581 laparotomies performed on a general surgical service at Crown Heights Hospital, Brooklyn, New York.

Perhaps the incidence would be better expressed in relation to the number of pregnancies admitted. On this basis, James and Lafferty<sup>6</sup> reported from Hahnemann Hospital, Philadelphia, 103 ectopics during a five-year period when 7,478 cases of term pregnancy, 254 miscarriages and 892 abortions were seen. This is an incidence of one in sixty-five pregnancies. Miller<sup>7</sup> reported during a similar five-year period fifty-four extra-uterine pregnancies to 7,452 abortions, miscarriages and full-term pregnancies, or an incidence of 1 to 136. It seems likely that both of these figures are high, since most ectopics are hospitalized sooner or later, while many abortions and pregnancies are treated entirely outside of a hospital. Schumann<sup>8</sup> has made the most careful study of this phase of the subject. By a comparison of the admissions to all hospitals in Philadelphia and the gross figures for births registered in that city, and after arbitrary correction of these figures, he computes the incidence at about 1:300.

#### ETIOLOGY AND PREDISPOSING FACTORS

It is evident in consideration of the etiology of tubal gestation that abnormal conditions in either one or both of two anatomic elements must be present; the salpinx, through which the ovum passes to reach the endometrial cavity, is changed anatomically or physiologically or there is some abnormality in the structure or be-

havior of the ovum itself, leading to an ectopic implantation. There is no evidence that the only other possible anatomic unit involved, the spermatagon, is a factor, except possibly in maldevelopment of the ovum.

On the basis of this generalization, the various etiologic factors suggested may be classified:

#### 1. Tubal

##### 1. Intrinsic:

- A. Developmental hypoplasia or abnormalities.
- B. Pathologic changes in the tubal wall, cilia or lumen due to pre-existing tubal inflammation.
- C. Changes in the tubal lumen following insufflation or salpingograms.
- D. Obstructing new growths in the tube or uterus.
- E. Endometrial implants in the tube.

##### 2. Extrinsic:

- A. Distortion of the tube due to:
  - (a) Pressure from new growths in the pelvis.
  - (b) Peritubal adhesions:
    - a. The result of previous pelvic inflammatory diseases.
    - b. The result of previous pelvic or appendiceal surgery.
    - c. The result of previous attacks of appendicitis.

#### II. Ovular

- 1. Intrinsic conditions in the ovum.
- 2. External migration of the ovum.

Cosgrove<sup>9</sup> has stressed that since fertilization of the ovum occurs invariably before it enters the uterine cavity, its nidation and development outside the uterus depend on many conditions which tend to interrupt or impede the progress of the ovum toward the uterus after it is fertilized. The occurrence of developmental abnormalities of, or new growths in, the tube, while certainly theoretically possible, is of only occasional importance, judging from the infrequency

with which they have been demonstrated as the likely causative factor. By far the most important consideration, according to most authors, is the existence of pathologic changes within the tube or peritubal adhesions outside the tube—the result of previous pelvic inflammatory disease.

Falk<sup>10</sup> has been a staunch advocate of prior infection as the usual cause. Basing his figures on a series of fifty ectopics in which a careful histologic study was made of the proximal end of involved tubes, he stated that 95 per cent of the cases showed the end results of low-grade infection. An acute gonorrheal salpingitis, on the other hand, may result in complete destruction of the epithelium and closure of the lumen with resultant sterility. Falk's figure is high, but the view that a large per cent of ectopics occur in tubes showing evidence of preëxisting tubal infection, gonorrheal, postabortal and puerperal, is shared by the majority of authors. Von Graff and Brown<sup>3</sup> cited 33 per cent in their series. Tyrone and associates<sup>11</sup> were impressed by the large percentage of salpingitis, 27.8 per cent of their cases showing microscopic evidence of tubal disease in the uninvolved tube. Masson,<sup>12</sup> reporting from the Mayo Clinic, found a history of previous pelvic disease in 46.9 per cent of his series.

In support of a salpingitis etiology, Hahn<sup>13</sup> stated that gonorrhea is the most common cause of extra-uterine pregnancy, basing this contention on the greater incidence of ectopics in large towns where gonorrhea is more prevalent. Falk<sup>14</sup> made the same observation in this country, stating the ectopics were more frequent in Harlem where the incidence of gonorrhea is notoriously higher than in certain Quaker settlements in Pennsylvania where both gonorrhea and extra-uterine pregnancy are rare. On the other hand, Litzenberg<sup>15</sup> stated that less than 10 per cent of his specimens showed positive evidence of pathology and Van Etten<sup>16</sup> found only 10.4 per cent of seventy-seven cases showing signs of previous or concurrent tubal inflammation and, including tubal adhe-

sions, only 31.3 per cent showing involvement by infectious processes. He stressed that round cell infiltration about an implanted ectopic gestation is the usual finding and does not indicate salpingitis. This diagnosis must be based on sections remote from implantation. As an additional cause of tubal infection and ectopic pregnancy, Potter<sup>17</sup> noted three cases in which patients developed tubal pregnancy while wearing gold stem pessaries. The etiologic rôle of contraceptives, especially of this type, has been stressed by other authors as well.

There have recently been cases of tubal pregnancy reported in the literature following tubal insufflation, which Tyrone and associates<sup>11</sup> explained by the presence of previous salpingitis. Insufflation reestablished the lumen sufficiently that conception could take place, but the peritubal adhesions and intramural changes were such that normal tubal peristalsis was interfered with and the lumen was narrow enough to prevent passage of a fertilized ovum. Mueller<sup>18</sup> believed that salpingograms might be a causative factor, but could cite no cases in his series to prove the point.

In 1914, McGlinn<sup>19</sup> called attention to the previous work of Webster in which he demonstrated the existence of the decidual reaction in all cases of tubal gestation and advanced the view that the fertilized ovum could develop only on tissues capable of undergoing the genetic reaction. He felt the occasional occurrence of this reaction in the Fallopian tube was to be regarded as a reversion in this tissue to an earlier mammalian type either in structure or in reaction tendency. Schenk and Frankel<sup>20, 21</sup> found in casual sections of ectopic tubes 62 per cent showing more or less well-defined decidual tissue. In a more careful study of sixteen specimens since 1934, they found fourteen of sixteen showing well-defined decidual tissue at the implantation site, the other two tubes being markedly distended with old blood. On the basis of these findings, they contended that this



was not an accidental but an incidental finding and that the etiologic factor in the production of ectopic pregnancy is the prior existence of endometrial tissue in an ectopic site, be it in the tube or intra-abdominally. In harmony with this idea all ectopic gestations are primary, in contradistinction to the generally accepted idea that abdominal pregnancies are secondary to aborted or ruptured tubal pregnancies.

Litzenberg,<sup>15</sup> however, concluded that there is no true decidua in the tube, that there is an ovum bed but no decidua basalis and very few decidual cells. Even in serial section he found such cells very infrequently. He felt that the supposed decidual cells were really trophoblastic, an error easy to make, especially when the trophoblastic cells are isolated or found in groups with no direct connection to the trophoblastic masses.

It seems likely that previous pelvic operations with the formation of adhesions may be a factor in some cases of tubal pregnancy. Lavell<sup>22</sup> reported that 26.8 per cent of his patients had had previous operations on pelvic organs and believed it might be inferred that the operation itself may have been a damaging factor predisposing to later ectopic gestation. Urdan<sup>4</sup> likewise reported 193 of 474 ectopic pregnancies in which previous pelvic surgery had occurred.

The rôle of the ovum in tubal gestation is difficult to evaluate, but the high incidence of abnormal development in ectopic gestations and of abnormal feti in abdominal pregnancies at or near term, would point to abnormality in the ovum as a possible factor in some cases.

The question of hormonal control is an uninvestigated field. External migration of the ovum, with delay in reaching the uterine cavity, and development to a point where it traverses the tube with difficulty has been suggested as a cause in some cases and proved in a few patients with previous unilateral oöphorectomy and salpingectomy on opposite sides.

Tubal pregnancy occurs in various races and patients of various nativity. Lavell<sup>22</sup> stated that apparently the racial and nationality incidence is in relation to the incidence in general hospital population. This view is shared by investigators who have made any study of this factor.

Tubal pregnancy may occur at any age during the child-bearing period. However, there is a disproportionate paucity of cases in the years before 20. Lavell stated that there is a noticeable concentration between 25 and 29 years. This is borne out by Miller<sup>7</sup> who found 50 per cent of his series between the ages of 20 and 30. Schumann,<sup>8</sup> in his exhaustive treatise on the subject, stated that 60 to 70 per cent occur between 24 and 33 years. This is perhaps the most reliable figure and is corroborated by other authors, including Scheffey and his associates<sup>2</sup> who found 74.3 per cent of their eighty-two cases fell in the age period between 23 and 35 years.

In general it has been felt that extra-uterine pregnancy is an accident occurring in the main in parous women, but this is not entirely true. Miller<sup>7</sup> found that 36 per cent of his 104 patients had never been pregnant previously. Brown<sup>23</sup> found that eleven of his sixty-two patients, or over 17 per cent, were nulliparous, and Urdan<sup>4</sup> found 21 plus per cent of his 474 patients gave no history of previous pregnancy. The larger groups of patients, however, have had one or more pregnancies ending in normal term deliveries or abortions. In general, the average number of previous pregnancies is given as between two and three.

Sterility is a factor difficult to evaluate and may be inaccurate for one of two reasons: (1) contraception may have been practiced and the sterility enforced, not actual; (2) 50 per cent of sterility is due to the male and has nothing to do with the female generative organs. The idea is prevalent, however, that ectopics most often follow a period of sterility. To be considered of importance a sterile period of more than three years may be arbitrarily

taken as of significance. On this basis Brown<sup>23</sup> found that 60 per cent of the patients in his series who had been pregnant gave a history of secondary sterility. On the other hand, Miller<sup>7</sup> felt it was questionable whether a period of relative sterility is more frequently found in this disease than in other conditions, such as pelvic tumor or gonorrhea, and Lavell<sup>22</sup> felt that after subtraction of those practicing contraception and those in which the male was at fault, there would be only a few who could be called relatively sterile. The occurrence of one-child sterility preceding an ectopic gestation was found by Urdan<sup>4</sup> to be about 12 per cent, which seems hardly high enough to be of any especial significance.

There can be little doubt that ectopic pregnancies occur more frequently in patients who have had previous ectopic pregnancies than in other women as a group. It is difficult to arrive at a figure representative of this recurrent likelihood. Various series report varying figures. To cite a few: Grier<sup>24</sup> found 3 per cent; Smith<sup>25</sup> found in an analysis of 1,608 cases operated upon by members of the American Gynecological Society 3.5 per cent; James and Lafferty<sup>6</sup> gave 4 plus per cent, as did Strassman<sup>26</sup> in a report from the Mayo Clinic; and Von Graff and Brown<sup>3</sup> found 5 per cent in their series repeating. These figures are in fairly close agreement, but not closely comparable with the figures of Giles,<sup>27</sup> who reported 12.8 per cent recurrence or of Smith,<sup>25</sup> who found in his own series 14.6 per cent having a second extra-uterine gestation. Rubin<sup>28</sup> had nine recurrences in ninety cases, or 10 per cent.

#### PATHOGENESIS

Of all ectopic pregnancies, 95 to 98 per cent are found to be tubal pregnancies. An occasional one is interstitial. Rarely an ovarian pregnancy is found, but whether any of these are truly ovarian is a debatable question. A relatively small number of abdominal pregnancies implanted in vari-

ous situations are reported. It was the opinion of most authors that this latter group was in most cases secondary to an expelled ovular product primarily implanted in the salpinx. The development of a pathologic picture in tubal pregnancy is dependent on the fact that, as Litzenberg<sup>15</sup> has so tersely expressed it: "The physiology is the same as in uterine pregnancy but the results will be pathologic because the ovum is implanted in an organ unfit anatomically or histologically for its reception." The primary step in the pathogenesis of tubal pregnancy, then, is implantation. The various ideas as to the cause of this ectopic implantation have been discussed.

Implantation takes place in the wall of the tube, on a tubal fold, as demonstrated by Somerfield<sup>15</sup> or perhaps on an endometrial transplant. It was the opinion of many authors<sup>12, 18, 22, 29</sup> that implantation occurred much more frequently in the ampullary portion than in the isthmic portion of the tube—roughly the predisposition for implantation increasing progressively from the uterus toward the fimbriated extremity. Polak<sup>30</sup> calculated this incidence as 76 per cent in the free end of the tube, 21 per cent in the isthmic end of the tube and 3 per cent interstitial. Whether a true decidua is formed following implantation in the tube is a moot question. Schenk and Frankel,<sup>20</sup> in advancing their endometrial etiologic theory of ectopic pregnancy, felt that usually endometrial tissue was present in the tube which by hormonal stimulation became decidual tissue. Moritz and Douglass<sup>31</sup> agreed that tubal decidua is frequently found and noted its development in twenty-six of fifty-three cases studied. Conversely, Falk<sup>32</sup> stated that the stroma of the tube usually does not undergo decidual changes to resist the digestive action of the trophoblast of the ovum, and Litzenberg contended that there is no true decidua in the tube, that there is an ovum bed but no decidua basalis and very few decidual cells. This question is principally of aca-

demic interest. Suffice it to say that the thin tubal wall is attacked by the blastocyte in essentially the same way as the thick uterine endometrium and that, with or without a thin decidua, the tubal wall is not capable of withstanding, except in very rare cases, the full development of the fetus.

Following implantation, growth of the ovum occurs in one of three ways—primarily deep into the tubal wall, principally into the tubal lumen, or both more or less equally. Sooner or later with progressive development of the blastocyte and deeper penetration of the trophoblast, small vessels are eroded and bleeding takes place. If the growth of the ovum is deep in the tubal wall, the result is, as pointed out by Falk,<sup>32</sup> either death of the ovum or external rupture. If the growth of the ovum is into the tubal lumen the result is appearance of blood at the vulva and in the peritoneal cavity through the fimbriated end (threatened tubal abortion), distention of the tube due to hemorrhage into it which cannot escape, or tubal abortion.

The result of this growth of the blastocyte in an ectopic position may be: Early death of the ovum with ultimate absorption; degeneration in a mass of blood to form a tubal mole; termination of the pregnancy by surgery before rupture or abortion; free rupture of the tube; threatened or complete abortion through the end of the tube; extrusion of the ovular product by rupture or abortion with the gravitation of the dead gestation product and blood into the pelvis to form a hematocele; secondary implantation of the extruded living gestation in the abdominal cavity; or, very rarely, progression to term in the tube.

It is conceded that when implantation takes place in the isthmic portion of the tube with its narrow lumen, free rupture is the usual end result and when implantation is near the fimbria, tubal abortion is the likely termination. There is, however, no uniformity in opinion as to the relative incidence of tubal rupture and tubal abor-

tion. It has been generally stated in the past that tubal abortion is the most frequent termination. A review of recently reported series in the literature does not, on the whole, bear this out. Urdan<sup>4</sup> in his large series found 48.31 per cent ending as tubal abortion with 37.7 per cent terminating in rupture. Hennessy<sup>29</sup> stated that 75 per cent of cases are found at operation to be tubal abortions and Koster and Scheinfeld<sup>5</sup> reported thirty-one cases of abortion to twenty-nine of tubal rupture. On the contrary, James and Lafferty<sup>6</sup> found forty-seven cases of tubal rupture to forty-two of tubal abortion. Lavell,<sup>22</sup> after a review of his large series, stated that rupture was three times as common as abortion. Scheffey and his associates<sup>2</sup> agreed with Lavell since they found fifty-three cases of tubal rupture with only sixteen of tubal abortion, and Fitzgerald and Brewer<sup>33</sup> reported a marked preponderance of tubal rupture in the proportion of 364 to 78. Many of the ectopic products at the time of operation are found to be on section in the state of a tubal mole.

The surgical discovery of an unruptured ectopic is not frequent. The incidence has been reported in various series<sup>2,4,6</sup> as from 5 to 13 per cent. Pelvic hematoceles in a more or less organized state are not a frequent finding; Urdan<sup>4</sup> found only six in 474 cases. The rarest termination of a tubal pregnancy is development within the tube to term. The report of its occurrence is limited to a few isolated cases. Schumann<sup>34</sup> reported such a case of his own and stated that several others had been reported. Such a termination presupposes a tube of unusual distensibility with implantation in the inferior margin where the blood supply is rich. It is superfluous to say that the fetus is likely dead when surgically removed. The same may be said to a lesser degree of secondary abdominal pregnancies, as reported by Ware.<sup>35</sup> This interesting subject does not come under the scope of this paper.

Coincidental with implantation of the fertilized ovum in the tube, certain changes

take place in the uterus. Enlargement of the uterus may occur and progress to a size usually not exceeding that of a two to two and one-half months pregnancy. What enlargement takes place is due in part to the formation of a true decidua in the uterus, responding to hormone stimulation. It is the general opinion that the decidua continues to develop until the ectopic gestation is disturbed by the death of the ovum at tubal rupture or abortion. Then the decidua degenerates and is cast off in shreds or as a more or less complete cast of the uterus and accompanied by some uterine bleeding. Sampson<sup>36</sup> concluded after a study of twenty-five uteri associated with ectopic pregnancy that uterine enlargement is due to: (1) hyperemia, (2) a thickening of the endometrium and possibly some increase in size of the muscle fibers. The changes which he found in the endometrium were quite similar to those found in the decidua vera of early uterine pregnancy. It was, however, the belief of Moritz and Douglass,<sup>31</sup> after a study of fifty-three endometria in cases of ectopic pregnancy, that a uterine decidua may be but is by no means constantly formed. In fact, they found a uterine decidua present in only eight of fifty-three cases and cited six cases in which they had definite proof that none had been formed since there was none found and no history of bleeding.

#### ANALYTICAL STUDY

During a period of ten years and ten months, seventy-three proved cases of tubal pregnancy have been seen in the Guthrie Clinic and the Robert Packer Hospital. During this same period of time 3,771 full term deliveries and 495 abortions were admitted to the hospital. This makes an incidence in this clinic of 73 tubal to 4,266 uterine pregnancies or a ratio of 1:58. This incidence is considerably higher than in the usual reported ratio, but this clinic is situated in a rural community in which only a fraction of the parturitions and abortions are cared for in a hospital, while of necessity most of the ectopic pregnancies

become hospital cases. This series included seventy two white patients and one colored patient; as this institution treats only an occasional colored patient, this racial proportion is to be expected.

The average age for the series was 29.15 years. The age range was 17 to 44 years

TABLE I  
AGE GROUPING

Ages	No. of Cases	Per Cent
15-19.....	3	4.1
20-24.....	18	24.6
25-29.....	16	21.9
30-34.....	22	30.2
35-39.....	9	12.3
40-44.....	5	6.9
Total.....	73	100.0

(Table 1.) It is notable in a perusal of this table that the largest number of cases falls in the five-year period between 30 and 34 years and that 52.1 per cent of the tubal gestations occurred in the decade between 25 and 34 years inclusive. This is comparable to the figure given by Schumann<sup>8</sup>—60 plus per cent occurring between the ages of 24 and 33 years. It is noteworthy that more cases occurred in the period above 40 than in the one below 20 years of age.

No attempt will be made here to influence the present etiologic concepts of tubal pregnancy, except to present such confirmatory evidence of preëxisting tubal infection as was found in this series. Twenty-five cases, or 34.2 per cent of the series, presented no definite history or findings of previous or concurrent tubal infection; twenty-one cases, or 28.8 per cent, showed definite gross pathologic evidence of previous infection in both tubes; 6 cases, or 8.2 per cent, were reported to have presented definite evidence of salpingitis in the ectopic tube. The condition of the other salpinx was considered normal or was not noted. In view of the very high incidence of salpingitis as a bilateral disease, it seems likely that most cases presenting pathology in the non-

ectopic tube also had varying degrees of change of possible etiologic significance in the tube harboring the ectopic. However, the architecture of the salpinx involved in tubal gestation is likely to be so distorted that the interpretation of gross changes by the pathologist may often omit mention of changes which on closer study of the specimen might be attributed to preexisting infection. In view of these facts we include 18, or 24.6 per cent of the cases, in which the surgeon or pathologist noted definite evidence of salpingitis in the opposite tube.

The majority of these cases with gross pathology present had changes in the size of the tube, thickness of the wall, and opacity of the lumen. A smaller number presented numerous peritubal adhesions as the only finding. In addition to these gross findings many of these patients gave a history of previous salpingitis—gonorrheal, postabortal or puerperal. Two additional patients gave such definite histories of previous infection, one of proved gonorrhea and one of a tubo-ovarian abscess drained two years prior to the ectopic gestation, that they are included as having a possible infectious etiology. The remaining patient had a concurrent appendicitis which by contiguity may have been a factor in causing the right ectopic pregnancy. This makes a total of forty-eight, or 65.8 per cent of this series, which presented in most cases pathologic, and in all of the remaining, a history of preëxisting tubal infection. This is strong evidence in favor of changes in the tube of a gross nature due to infection as the etiology of ectopic pregnancy in a large percentage of cases. Because serial sections of the tubes were not made, no opinion can be expressed as to the presence or absence of endometrial tissue implants in these cases.

One patient had two tubal pregnancies operated upon in the span of years covered by this study. One patient gave a history of a previous salpingectomy for tubal pregnancy and a third had a lithopedion found in the opposite tube at the time of

operation. This was considered definite evidence of a prior tubal gestation in which the fetus had died and become calcified before rupture or abortion took place. In all there were three cases in this series with recurrent ectopics. This is an incidence of about 4 per cent and is in close agreement with the figures of James and Lafferty<sup>6</sup> and Strassmann<sup>26</sup> and the incidence in the composite series cited by Smith.<sup>25</sup>

In this series four patients were unmarried. Of the sixty-nine married patients, the history recorded the marital period in thirty-one. The shortest period from marriage to operation for tubal pregnancy was six months, the longest twenty-seven years. The average marital period in this group was 9.74 years, which confirms the usual opinion that ectopic pregnancies occur usually after a fairly long marital period. Fifty-six of the seventy-three case records studied specified as to previous pregnancy and the number of previous gestations. Twelve, or 21.4 per cent of those in which the obstetrical history was given, had not been previously pregnant. This figure is closely comparable to that given by Urdan.<sup>4</sup> Forty-four, or 78.6 per cent of those specified, had been pregnant prior to their tubal gestation. The number of pregnancies ranged from one to eleven and averaged 2.82 pregnancies, ending in abortion or full term delivery. Thirty-nine case histories specified the time of sterility; five of these indicated primary sterility averaging 2.7 years; thirty-four a secondary sterility. The average sterile period was 2.83 years, which is below the arbitrary three-year sterility which may be regarded as significant, but eighteen of these thirty-four cases, or over 50 per cent with secondary sterility, had a sterile period of over three years. The figures on this point are not complete enough in this series to be conclusive, but suggest the presence of a sterile period immediately preceding the ectopic gestation in a sizable percentage of cases. Thirteen of the fifty-six patients giving a complete obstetrical history had had one pregnancy each. The sterile period

was specified in ten of these cases and averaged 5.25 years. Six patients had had a sterile period of over three years. This is suggestive of a fair incidence of one pregnancy sterility in this series.

The cases covered in this analysis were classified as to the pathology present. Those cases in which there was a gross rent in the tube with blood in the peritoneal cavity, encapsulated or free, were classified as ruptured. Those in which there was no demonstrable tear in the tube wall but gross bleeding into the peritoneal cavity were classified as tubal abortion, more often threatened than complete. Only those cases with no rent in the tube and no bleeding into the peritoneal cavity and with a localized distention of the tube containing a gestation product or tubal mole were classified as unruptured.

TABLE II  
PATHOLOGY

	No. of Cases	Per Cent	Right Tube	Left Tube
Ruptured.....	31	42.5	17	14
Abortion.....	31	42.5	16	15
Unruptured.....	11	15.0	5	6
Total.....	73	100.00	38	35

It is to be noted that the incidence of rupture and abortion is exactly the same in this series. An incidence of 15 per cent unruptured cases is higher than in most reported groups of cases. In a number of cases rupture or abortion took place into preformed adhesions with the formation of a localized hematocele. In others the gestation product and blood gravitated to the pelvis, becoming more or less organized as a pelvic hematocele prior to operation. These were not differentiated from those cases with blood found diffusely throughout the abdomen because it was possible to distinguish the pathogenesis and classify them as to the causative process—i.e., rupture or abortion. Pregnancy occurred in the right tube in thirty-eight and in the left tube in thirty-five, a difference not great enough to be of any significance.

## DIAGNOSIS

The diagnosis of tubal pregnancy is difficult. Mistakes in diagnosis are all too frequent in all reported series. DeLee<sup>37</sup> stated: "No pelvic condition gives rise to more diagnostic errors. The author has seen mistakes made by every gynecologist and surgeon in the city, including himself." So-called typical cases are seen infrequently, in fact, as Litzenberg<sup>15</sup> has noted, "The most typical thing about an extra-uterine pregnancy is that it is atypical." There are cases of frank rupture exhibiting evident signs of intra-abdominal hemorrhage, shock, typical pain or rupture and a history of amenorrhea followed by vaginal bleeding in which the diagnosis is evident. Fortunately for the patient, this "tragic" type of case is in the minority. On the other hand, the unruptured case is seldom correctly diagnosed. It is true that because of minimal symptoms many of these patients are not seen by the physician or surgeon until the further developments of abortion or rupture take place. It is equally true that many of these unruptured ectopics are seen by the surgeon who treats them conservatively or operates on them with a diagnosis other than tubal pregnancy. In between these two groups are the majority of cases seen on a surgical or gynecological service—those with varying degrees of hemorrhage in the stage of threatened or complete abortion or rupture without startling hemorrhage. In many of these the diagnosis is readily made and treatment promptly carried out. In others because of confusing factors in the history or misleading findings, the correct diagnosis is made only after considerable study, only suspected or not made preoperatively at all.

The literature abounds with reports of missed diagnoses; to mention but a few: Miller,<sup>7</sup> in 104 cases, reported diagnoses correct in 35 per cent, suspected in 35 per cent and incorrect in 30 per cent. Von Graff and Brown<sup>3</sup> stated that even in well-equipped and efficiently supervised institutions as many as 30 per cent of all ectopics



are surprises discovered during operation. Urdan,<sup>4</sup> in his large series of 474 cases, found the diagnoses correctly made preoperatively in only 58.17 per cent and suspected in fifty more cases. Excluding cases in his series prior to 1918, Lavell<sup>22</sup> found a diagnostic error of only 15.3 per cent—one of the best reports in the literature.

The series of seventy-three cases here reported likewise shows too high a proportion of missed diagnoses; forty-six cases, or 63 per cent, were correctly diagnosed before laparotomy, ten following a diagnostic dilatation and curettage. In three cases, or 4.2 per cent, the diagnosis was suspected but not unequivocally made and in twenty-four, or 32.8 per cent, the preoperative diagnosis was something other than tubal pregnancy.

It is generally conceded that the two conditions with which ectopic pregnancy is most often confused are pelvic inflammatory disease and uterine abortion. In this series fourteen cases were incorrectly diagnosed as salpingitis, pyosalpinx or pelvic inflammation. In ten cases the diagnosis of uterine abortion was considered seriously enough to warrant a diagnostic curettage in order to exclude it. The remaining errors included the diagnosis of appendicitis in three cases, fibromyomata of the uterus in three, ovarian cyst in three and adherent retroversion of the uterus in one case.

In the differentiation of salpingitis or pyosalpinx the most important single point is that tubal inflammation is usually bilateral, whereas the mass when palpable in ectopic pregnancy is unilateral. In addition, the menstrual change associated with salpingitis is usually menorrhagia with a shortened intermenstrual interval in contradistinction to a period of amenorrhea followed by scant flow in ectopic gestation. Of greater importance is the usual history in tubal infection of previous attacks of pain aggravated at the time of the period and the absence of all symptoms and signs of early pregnancy. Usually salpingitis is accompanied by a rather marked febrile

and leucocytic reaction with an increased sedimentation rate.

Davis<sup>38</sup> has nicely summarized the differential diagnosis between uterine abortion and tubal pregnancy. He stated that abortion is likely to occur at a later date than tubal abortion or rupture so the period of amenorrhea is longer before bleeding begins—on an average, four to six weeks in ectopic and eight to twelve weeks in abortion. The onset of pain in tubal pregnancy is often attended by dizziness or faintness or is stab like in the affected side, whereas it is almost always cramplike in uterine abortion. Vomiting is infrequent in abortion but common in ectopic pregnancy. Bleeding is small in amount and usually dark and sometimes brown in color in tubal gestation, whereas in abortion it is usually bright red, copious and may contain clots. In uterine abortion the external bleeding is an accurate index to the amount of blood lost, which is frequently not the case in an ectopic with considerable intraperitoneal hemorrhage. The findings in abortion are a uterus of size commensurate with the duration of amenorrhea, while in tubal pregnancy on bimanual examination the uterus may be slightly enlarged and often a unilateral, very sensitive and boggy mass is felt.

The differential diagnosis of tubal pregnancy seems definite enough on paper, but in actual practice there are many cases in which there are factors in the history or findings which mislead one to the point of making an erroneous diagnosis. The symptoms of greatest frequency in ectopic pregnancy are pain, period of amenorrhea, vaginal bleeding and syncope or shock. When grouped together in a woman of the child-bearing age, they invariably suggest ectopic pregnancy, but none of these symptoms is constant and it is in only the occasional case that we find them grouped to present the so-called typical picture of ectopic gestation. It is felt that because the symptomatology and findings will vary somewhat, depending on the stage of the gestation, as to whether unruptured, rup-

tured or in process of tubal abortion, the case histories might best be analyzed clinically in relation to the pathology found at operation. An attempt has been made in the review of these seventy-three cases to do this and any notable differences in symptoms and findings between these groups will be emphasized.

Pain of some degree is the most constant symptom of tubal pregnancy. Grier<sup>24</sup> found pain present in all of his one hundred cases but Von Graff and Brown<sup>3</sup> have emphasized the fact that a tubal pregnancy may exist without pain, and Falk<sup>32</sup> in his comprehensive discussion of the subject stated that there is no pain until hemorrhage takes place since a normally growing ovum in a tube causes no pain. In this series, pain was almost a constant complaint, present

crampy, of only moderate severity, more often continuous than intermittent, and was in all cases, limited to the lower abdomen, usually to the quadrant containing the involved tube. In contrast, the pain in the ruptured case was most frequently sharp, at times crampy but never specified as dull in nature, usually severe and more often continuous than intermittent, and was described as generalized or upper abdominal in about 35 per cent of the cases. The pain in cases terminating in abortion was likewise predominantly sharp in character, but in over 80 per cent of the cases in which it was noted, was intermittent in occurrence, most often severe, but less often than in ruptured cases, and, in the majority of cases, was felt across all of the lower abdomen. In only four cases

TABLE III  
PAIN

Pathologic Diagnosis				Average Time Preop- erative First Noted, Days	Type				Con- tinuity			Severity				Position Abdominal Pain					Referred Pain									
	Present	Absent	Not Noted		Sharp	Crampy	Dull	Not Noted	Continuous	Intermittent	Not Noted	Slight	Moderate	Severe	Not Noted	General	Upper Abd.	Lower Abd.	Peri-Umbilical	R.L.Q.	L.L.Q.	Not Noted	Shoulder	Chest	Back	Thigh	Rectum	Vagina or Vulva	Pain on Urination	Pain on Defecation
Ruptured tubal pregnancy....	30	0	1	18.6	8	5	0	17	12	8	10	0	6	20	4	6	4	8	0	8	2	2	4	0	1	1	1	2	1	4
Tubal abortion..	31	0	0	22.6	10	6	3	12	4	18	9	1	9	15	6	3	1	15	0	4	7	1	3	1	4	1	2	1	1	6
Unruptured tu- bal pregnancy	10	1	0	27	2	3	2	4	4	2	5	1	8	1	0	0	0	3	1	4	2	0	0	0	0	0	0	0	1	0
Total.....	71	1	1	21.5	20	14	5	33	20	28	24	2	23	36	10	9	5	26	1	16	11	3	7	1	5	2	3	3	3	10

in seventy-one cases, not noted in one and specified as absent in only one case, which was an unruptured early case. (Table III.) The average time of onset of pain before operation was 21.5 days, being longest in the unruptured case which seems paradoxical, but is probably accounted for by the lesser severity of the pain in contrast to the case which terminated early in rupture or abortion and was forced to seek surgery early. As will be noted in Table III, the pain in unruptured cases was most often dull or

was it described as generalized or upper abdominal.

The differences in pain in these three pathological types are in accord with the pathogenesis, since in tubal abortion there is usually spasmodic expulsion of blood into the peritoneal cavity, causing intermittent pain as emphasized by Falk;<sup>32</sup> blood is more likely to be limited to the lower abdomen, and only occasionally in abortion do we have profuse hemorrhage with generalized pain. Cases which have termi-



nated by rupture include most of the instances of free abdominal hemorrhage in which blood is found at operation diffused throughout the abdomen and causing generalized pain. Because of the localized nature of an unruptured tubal gestation, we would expect pain limited to the side of involvement or at least to the lower abdomen.

In addition to pain in the abdomen, some patients complain of pain referred to other sites. The most frequent and most diagnostic referred pain is to the shoulder. This reference was first noted and reported by Rubin<sup>39</sup> in 1923 and has been since fre-

present in four ruptured cases and three cases of tubal abortion, an incidence of 9.6 per cent. In addition, reference to the chest, back, thigh and external genitalia was noted in a few cases. Three patients noted reference of pain to the rectum. It is noteworthy that no patients with unruptured tubal pregnancy had pain referred to any of these sites. Abdominal pain on urination or on defecation has been stressed by some writers and occurred three and ten times respectively in this series.

A "missed period" is the first presumptive sign of intra-uterine pregnancy. So, too, it is in some cases of tubal pregnancy

TABLE IV  
AMENORRHEA AND BLEEDING

Pathological Diagnosis	Amenorrhœa				Bleeding															
	Present	Absent	Not Noted	Average Period Where Present, Days	Present	Absent	Not Noted	Average Time Preop. First Noted, Days	Continuity			Amount					Character			
									Continuous	Intermittent	Not Noted	Slight	Moderate	Marked	Profuse	Not Noted	Brown Vaginal Flow	Dark Vaginal Flow	Clots	Tissue
Ruptured tubal preg- nancy.....	19	12	0	24.8	22	8	1	20.3	16	3	3	3	4	6	1	8	2	0	5	0
Tubal abortion.....	15	11	5	14.6	26	4	1	23.7	19	7	0	10	11	2	0	3	1	3	4	2
Unruptured tubal preg- nancy.....	4	6	1	16.5	9	1	1	31	5	4	0	2	5	1	0	1	0	1	3	0
Total .....	38	29	6	19.9	57	13	3	23.5	40	14	3	15	20	9	1	12	3	4	12	2

quently reported. Pain in either or both shoulders is accepted as an indication of blood between the liver and diaphragm causing phrenic irritation so presupposes rupture or abortion, with considerable free blood in the peritoneal cavity. Since Rubin's interpretation of this phenomena, many authors including Miller,<sup>7</sup> Gordon,<sup>40</sup> Mathieu,<sup>41</sup> Mueller,<sup>42</sup> and others have stressed its value as a symptom. Falk<sup>32</sup> gives its occurrence as 8 per cent in ectopics. Grier<sup>24</sup> found it present in 14 per cent of his series and Fitzgerald and Brewer<sup>33</sup> noted it in 8.2 per cent of their cases. In this series, shoulder pain was

the first symptom. This valuable indication of pregnancy, intra- or extra-uterine, is unfortunately not always present. Urdan<sup>4</sup> has summarized the onsets of anomalous bleeding: (1) Most commonly after a period of amenorrhea; (2) at the time of the regular period but continuing; and (3) one to three weeks after a regular period. It is evident that those cases falling in the last two groups will have missed no periods.

According to most reports some period of amenorrhea was present in a majority of cases. Falk<sup>32</sup> found a history of "missed period" in 85 per cent of his series. Miller<sup>7</sup>

and Grier<sup>24</sup> found such a history in 79 and 76 per cent of their cases respectively. Urdan,<sup>4</sup> however, found amenorrhea noted in only 60 per cent of his series and Brown<sup>23</sup> and Von Graff and Brown<sup>3</sup> said less than one-half of their patients missed a period. Of the sixty-seven cases of this series in which the history was specific on this point, only 56.7 per cent of the cases reviewed had had a period of amenorrhea, averaging about twenty days. (Table iv.) It is significant that the average period of amenorrhea in ruptured tubal pregnancy was over ten days longer than in the cases of tubal abortion, indicating that vaginal bleeding starts earlier in cases with luminal implantations which are likely to progress to abortion than in mural implantations which are likely to end in rupture of the tube. This is in accord with the ideas of Falk<sup>32</sup> on tubal implantation.

A history of anomalous bleeding is more frequently encountered than is orderly amenorrhea followed by bleeding.

Polak (quoted by Johnston<sup>42</sup>), found a history of menstrual disturbance in 95 per cent of his series. This figure is probably fairly correct. In this series, over 90 per cent of the patients gave a history of either amenorrhea or anomalous bleeding or both. Vaginal bleeding is probably in most cases uterine in origin, due to decidual slough secondary to disturbance in the implantation of the ovum, but it seems likely that blood originating in the tube at times finds its way to the introitus. Falk<sup>32</sup> believes that it is blood from the tube which is noted as dark brown or black in color when seen externally, and which is so typical of ectopic when present. Abnormal external bleeding was present in 81.4 per cent of this series. (Table iv.) This is in accord with most reported figures in the literature which ranged from 80 to 90 per cent. The bleeding started on an average of 23.5 days before operation and continued to the time of operation as a more or less uninterrupted flow of small amount in the majority of cases. In seven cases, or about 10 per cent of the series, the flow was designated as

dark, brown or black in color. Clots were noted in twelve instances and definite tissue in two. It seems likely that both of these were decidual tissue. There were no differences in the character of bleeding constant enough to be of diagnostic value between the various pathologic types of tubal pregnancy.

Subjective symptoms of pregnancy, especially morning sickness and breast changes, have been emphasized in the past by some authors. Most recent writers have specifically stated that they are infrequent or "conspicuous by their absence." This view was shared by Miller,<sup>7</sup> Urdan,<sup>4</sup> Lavell,<sup>22</sup> Ludwig,<sup>43</sup> Bell<sup>44</sup> and others. Breast changes were noted by the patient only four times in this series. It is true that nausea or vomiting are frequent, noted forty-three times in this series, but this study does not bear out the idea of Falk<sup>32</sup> that the nausea and vomiting is usually a symptom of pregnancy per se, because in only six cases was it regularly recurrent, suggesting morning sickness, whereas in the remaining cases the sequence clearly suggested nausea or vomiting secondary to pain.

The fourth group of symptoms suggestive of eccyesis includes those of syncope, varying from a mild feeling of faintness in cases of lesser severity to profound shock with all of its symptoms and findings. As will be noted in Table v, the symptoms of faintness and the findings of pallor, poor pulse volume, or prostration were almost limited to those cases which had progressed to tubal rupture or abortion, being most common in cases of tubal rupture. One patient with an unruptured tubal pregnancy had noted faintness and one had fainted on one occasion prior to operation. This subject will be discussed further below.

In those patients who had preoperative blood pressure recorded, the systolic reading varied with the pathology present (Table v), being lowest in cases of frank rupture, median in cases of tubal abortion and essentially normal in unruptured tubal

gestations. Conversely, the average pulse rate was highest in ruptured cases, median in cases of tubal abortion and lowest in unruptured tubal gestations.

TABLE V  
SYMPTOMS AND SIGNS OF SYNCOPE AND SHOCK

Pathologic Diagnosis	Pallor	Fainting and Fainting	Poor Pulse Volume	Prostration	Preoperative B.P. Given	Average Systolic B.P.	Preoperative Pulse Given	Average Pulse Rate
Ruptured tubal pregnancy.....	16	6	5	5	18	108	30	107
Tubal abortion.....	7	3	4	4	13	118	29	96
Unruptured tubal pregnancy.....	0	1	1	0	5	122	11	89
Total .....	23	10	10	9	36	113	70	99.6

The temperature in this series ranged from 95 degrees in a ruptured case in shock to 101.8 degrees, in a case of tubal abortion with pelvic hematocele. The average temperature was 99°F., but this figure means little since it balances those low in shock with those above normal due to peritoneal irritation. In the unruptured cases, the average temperature was 98.8 with a range of only 98.4 to 99.4, essentially normal. It is generally agreed that the temperature may rise immediately following liberation of fresh blood into the peritoneal cavity, which in the absence of infection soon falls to normal. This rise is not high, usually not over 2 to 2.5 degrees. Ricci and Di Palma<sup>45</sup> have stressed the fact that temperature is no index to the amount of intra-abdominal blood, although low temperatures will be found, of course, in cases of marked hemorrhage and shock.

On palpation of the abdomen, tenderness is an almost constant finding. Most authors<sup>2,7,18,22,24</sup> noted abdominal tenderness of varying degree in 85 to 95 per cent of their cases. In this series 95 per cent had some abdominal tenderness. (Table VI.) Tenderness was entirely absent in two unruptured cases and in one case of tubal abortion. The tenderness was moderate or marked in most cases of tubal rupture or tubal abortion and slight or moderate in unruptured cases. The localization of

tenderness was comparable to the position of pain, being predominantly generalized or across all of the lower abdomen in rupture or abortion and localized to the quadrant containing the involved tube in unruptured cases. In general marked tenderness is due to the presence of blood in the peritoneal cavity, whereas the tenderness of an unruptured ectopic is localized and not marked.

Brown,<sup>23</sup> Cosgrove,<sup>9</sup> and Johnston<sup>42</sup> have mentioned abdominal rigidity as the usual finding, with blood in the peritoneal cavity. Gordon<sup>40</sup> stated that rigidity is often unilateral and less marked than in acute appendicitis and salpingitis. The finding of rigidity in only four of our cases of tubal rupture and five cases of tubal abortion is rather in agreement with the statement of Urdan<sup>4</sup> that rigidity is not a common finding. Its presence would tend to indicate that fresh blood was free in the abdomen and it is absent in unruptured cases. Falk<sup>32</sup> has recently stressed the rather frequent finding of abdominal distention due to a moderate ileus developing reflexly as a result of blood in the peritoneal cavity. In the sixty-two cases of tubal rupture and tubal abortion in this series, nineteen, or 30 per cent, had distention which was moderate in fifteen and marked in four instances. That distention would be absent in unruptured cases is self-evident.

In 1919, Cullen of Baltimore, described a case in which he noted bluish-black discoloration of the umbilicus.<sup>46</sup> This subsequently proved to be an ectopic pregnancy with the abdomen filled with blood and the phenomenon was considered a result of the oxidation of blood pigments deposited in the tissue through periumbilical lymphatics. This phenomenon, now called Cullen's sign, has been observed occasionally since. Novak<sup>47</sup> observed it twice prior to 1922 and other writers have reported single instances. Smith and Wright,<sup>48</sup> after a review of the literature, concluded it was a rare finding. It is not pathognomonic but very suggestive of ruptured ectopic pregnancy when present.

In this series, Cullen's sign was observed in one case.

Unilateral dilatation of the pupil on the side of rupture, probably due to vagus reflex from subdiaphragmatic irritation, has been reported but is rare and was not noted in this series.

Upon pelvic examination, which must be carried out with extreme gentleness in a suspected ectopic pregnancy, tenderness is usually found. The tenderness is likely to be more marked than on abdominal palpation and is at times exquisite in some cases

on a hematocele in the pelvis or about the tube, or direct pressure on the involved portion of the salpinx. This explains the greater incidence of bilateral tenderness in tubal rupture which is more often accompanied by free bleeding than in tubal abortion where the bleeding into the peritoneum is often intermittent and forms a localized hematocele in the pelvis or about the end of the tube. Obviously, in unruptured cases with no intraperitoneal bleeding, tenderness will usually be localized to the pathologically involved organ.

TABLE VI  
TENDERNESS AND PELVIC MASS

Pathologic Diagnosis	Abdominal Tenderness												Pelvic Tenderness								Pelvic Mass											
	Present	Absent	Not Noted	Severity			Position			Present	Absent	Not Noted	Severity			Position			Felt	Not Felt	Not Noted	Size			Position							
				Slight	Moderate	Marked	Not Noted	General	Low Abdominal				R.L.Q.	L.L.Q.	Both Sides	Right Side	Left Side	Cul de sac				Small	Moderate	Large	Not Noted	Right Side	Left Side	Back of Uterus				
Ruptured tubal pregnancy.....	30	0	1	3	9	12	6	9	14	7	0	23	1	7	1	3	16	3	12	7	3	1	13	14	4	2	2	3	6	7	4	2
Tubal abortion.....	30	1	0	6	7	7	10	2	11	10	7	24	0	7	2	5	13	4	9	7	7	1	24	5	2	12	1	4	7	11	12	1
Unruptured tubal pregnancy.....	8	2	1	2	3	2	1	0	1	4	3	10	0	1	4	2	3	1	1	3	6	0	9	2	0	7	1	0	1	3	6	0
Total.....	68	3	2	11	19	21	17	11	26	21	10	57	1	15	7	10	32	8	22	17	16	2	46	21	6	21	4	7	14	21	22	3

of rupture or abortion. From the findings in this series (Table vi), in which pelvic tenderness was specified as absent in only one case, we may say that in unruptured tubal pregnancy tenderness is usually present, is in the majority of cases slight or moderate in severity, but may be rather marked, and is almost always limited to the side of the involved tube. In tubal rupture the tenderness is predominantly marked in severity and is more frequently noted in both fornices than as limited tenderness on one side. In tubal abortion, tenderness is likewise usually marked in severity but is more often unilateral than bilateral. The presence of pelvic tenderness depends on free blood in the pelvis which is usually bilaterally distributed, pressure

Schumann<sup>s</sup> has stressed the point that traction on or motion of the cervix or uterus greatly aggravates the pelvic pain and tenderness. This was observed and recorded in the study in only sixteen cases of which fourteen were of tubal rupture or abortion. In only four instances was pain on motion of the cervix described as severe. Palpation of a pelvic mass is by no means constant. In this series, in forty-six cases a mass was felt on pelvic examination, no mass was felt in twenty-one cases and in six cases this information was not specified. (Table vi.) In general, a mass is more often palpated in tubal abortion than in tubal rupture due to the greater frequency of hematocele formation in the former. In unruptured cases, the mass is

small and may or may not be felt, depending on its size, accessibility and the acuity of the examiner. In all but three cases in which the mass was felt back of the uterus, it was limited to one side or the other. The mass is usually tender, at times exquisitely so, but sometimes, as stressed by Lavell<sup>22</sup> surprisingly free from marked tenderness. The mass is usually soft or doughy, seldom firm or hard. Bogginess in the cul-de-sac was noted in our patients in six cases of tubal rupture and four cases of tubal abortion, or about 15 per cent of the patients who had blood in the peritoneal cavity.

Since there is the same hormone control of the reproductive organs operating in a tubal gestation as in a normal pregnancy and in most cases a decidua vera formation in the uterine body, we would expect in tubal pregnancy the changes in the generative organs found in a normal pregnancy, principally softening of the cervix and enlargement of the uterus. These changes exist, but are not always clinically evident due to the early termination of the extra-uterine gestation or because the changes are not gross enough to be noted on examination. Mueller<sup>18</sup> reported softening of the cervix in 26 per cent and enlargement of the uterus in 28 per cent. Ludwig<sup>13</sup> reported enlargement of the uterus to the size of a two to two and one-half months' pregnancy, which is the usually given extent of enlargement in extra-uterine pregnancy, in nine of his 145 cases. Scheffey and his associates<sup>2</sup> noted enlargement of the uterus and softening of the cervix in 19.5 per cent. These figures are in accord with Lavell's<sup>1</sup> statement that the signs of pregnancy are absent in the majority of cases. In the seventy-three cases considered in this report, thirty, or 41 per cent, showed either softening of the cervix, enlargement of the uterus or both. The uterus was considered larger than normal in eighteen cases, slightly enlarged in fourteen and moderately so (size of two to two and one-half months' pregnancy) in four. The cervix was considered soft in nineteen cases.

Chadwick's sign was reported present in one case.

The laboratory is, of course, of some aid in the diagnosis of tubal gestation. The most important information gained is through the leucocytic response of the organism to blood as a peritoneal irritant, the erythrocytic and hemoglobin depletion as an evidence of hemorrhage and in recent years the evidence of pregnancy gained from the various biologic tests for pregnancy. The average results are given in Table VII.

TABLE VII  
LABORATORY FINDINGS

Pathologic Diagnosis	Specimen	Preoperative Leucocytes		Preoperative R.B.C. and Hemoglobin		Friedman Test	
		Average Count	Polys. Per Cent	Erythrocyte Count Given	Hemoglobin Per Cent	Performed	Positive
Ruptured.....	25	12,280	80.2	23,337,000	64.3	1	1
Abortion.....	28	11,440	77.3	20,342,000	60.5	4	4
Unruptured...	7	9,015	75.5	5,397,000	83.6	1	1

It is an accepted fact that following a fresh intra-peritoneal hemorrhage there is a prompt rise in the total leucocyte count and in the proportion of polymorphonuclear cells. However, Falk<sup>32</sup> stated that the count goes down rapidly after fresh hemorrhage ceases. The leucocyte count and differential, then, are of most value as an index to present or recent hemorrhage. A normal count does not indicate that there may not have been a large hemorrhage some time before the count was taken. Generally, the average count was highest in the ruptured cases of the series, median in tubal abortion, and lowest in unruptured cases with the polymorphonuclear percentage in relation. The highest count in the series was 26,000 with 94 per cent polys in a case of ruptured tubal pregnancy. Many counts were normal in the various groups.

The erythrocyte count and hemoglobin are of value as an indication to the blood lost vaginally and intra-peritoneally, but are not, of course, a true index immediately after the blood loss. The average counts

were lowest in tubal rupture and highest in unruptured cases. Because of the inherent errors in the biologic pregnancy test, the early stage in pregnancy when it is used in tubal gestations, and the fact that after complete separation of the gestation product or degeneration of the chorionic villi the test is no longer positive, causes frequent negative readings. Von Graff and Brown<sup>3</sup> and others have insisted that a positive test is of great aid, but a negative test inconclusive. The experience with the Friedman test in this series has been conclusive. It has been utilized in six cases, all of which were positive. This is unusual, since Goldberg, Salmon and Frank,<sup>49</sup> using the Friedman test in duplicate in ectopics, found 32 per cent false negatives.

The sedimentation test has been advocated to differentiate pelvic inflammatory disease from ectopic pregnancy. It was used only once in this series. The sedimentation rate in this case was within normal limits and so tended to rule out pelvic inflammatory disease. Dumphy and Fallon<sup>50</sup> have advocated the use of the quantitative Van den Bergh and serum bilirubin tests since these are elevated in the presence of intra-peritoneal hemorrhage. For the same reason, urobilinogen and icterus index determinations have been suggested. In this series, a positive urobilinogen and an icterus index of 15 were reported in one case with blood intraperitoneally. A normal icterus index was obtained in one unruptured case.

The Wassermann reaction was positive, 2 to 4 plus, in three cases.

There are several diagnostic procedures which are of great aid in some cases. There were ten cases in this series in which the clinical picture was such that uterine abortion could not be entirely excluded as a possibility. In these ten cases a diagnostic dilatation and curettage was done and, following negative findings, a laparotomy. Many writers<sup>1,2,7,11</sup> have felt that diagnostic dilatation and curettage is a procedure to be avoided when ectopic pregnancy is considered a possibility because of the

danger of rupture of the pregnant tube or of infection. In this study there was no indication that this is the case, since no complications arose attributable to curettage. The conclusion to be drawn is in accord with that of Siddall and Jarvis,<sup>51</sup> Siddall,<sup>52</sup> Moritz and Douglass<sup>51</sup> and Mathieu<sup>41</sup> that the procedure offers information in doubtful cases which well compensates for any theoretical danger in its performance. The value of a negative curettage alone is that it usually adequately rules out uterine abortion. In addition, the finding of decidua without chorionic villi is highly suggestive of ectopic gestation.

Needling of the cul-de-sac has been advocated in cases with bogginess in the cul-de-sac to palpation. Both Von Graff and Brown<sup>3</sup> and Mathieu<sup>41</sup> advocate it as a valuable procedure, warning of its danger from an infectious standpoint. It should be done as a preliminary to laparotomy. In this series, this procedure was used in only one case, in which it was diagnostic. Mathieu<sup>41</sup> has stressed hysterosalpingography as a valuable diagnostic aid. He stated that with the use of iodized oil the method gives practically 100 per cent positive evidence in support of or against tubal pregnancy as the diagnosis, and that there is no harm from the procedure. Smith and Brunner<sup>53,54</sup> first described, in 1934, modification in the vaginal mucous membrane in early pregnancy which they felt could be used as an accurate simple biopsy test of pregnancy. The rapidity with which a report may be obtained would recommend it, but its limited applicability except in an institution with a pathologist well trained in recognition of microscopic changes in the vaginal mucosa is evident. Hope,<sup>55</sup> in an interesting paper on the subject, stressed the applicability of peritoneoscopy to diagnosis of extra-uterine pregnancy. Hemoperitoneum is presumptive evidence of tubal abortion or rupture. He felt the procedure was simple, safe and accurate. These last three diagnostic procedures have not been used in any case in this series.

## THE SHOCK SYNDROME

Since the earliest descriptions of tubal pregnancy as a clinical entity, syncope and shock of varying degree have been stressed as symptoms and findings of tubal abortion or rupture. It is true that they do not always occur, but it is equally true that the presence of momentary faintness, history of fainting or evidence of actual shock, occurring in a woman with a clinical picture compatible with such a diagnosis, is highly suggestive of tubal pregnancy. In many of these patients the cause of the shock syndrome exhibited is adequately explained by the severe intraperitoneal hemorrhage found at operation. In the experience of many surgeons, however, an occasional case stands out in bold relief because, in spite of unmistakable clinical evidence of severe shock preoperatively, at operation very little evidence of intra-abdominal hemorrhage as the etiologic factor is found. This experience has raised the question in the minds of some, whether in many or even most cases of tubal abortion exhibiting varying degrees of shock there is adequate explanation for the shock, in the blood lost from the circulation of the organism.

In 1907, Hunter Robb showed that both uterine and ovarian arteries and veins might be severed without killing experimental animals (cited by Gordon<sup>40</sup>). He concluded that rarely was the hemorrhage in ectopic rupture sufficient to cause death per se, but that death was due, in addition to shock, to manipulation and release of abdominal tension by laparotomy with the removal of accumulated large quantities of blood. These views of Robb's, expressed before the general use of transfusion as a therapeutic measure, raised a bitter controversy over the advisability of immediate laparotomy in ectopic pregnancy. However, this controversy has been almost forgotten, Robb's experiments have never been demonstrated in the human subject, and his views have never been generally accepted, although never properly refuted.

With this background, the cases in this series exhibiting the shock syndrome in a moderate, marked or severe degree have been segregated and an attempt has been made to analyze both the evidence of shock on the one hand and of hemorrhage on the other, to see if any grossly appreciable disparity exists which might be interpreted as indicating that other factors than hemorrhage usually play a significant part in the production of the shock picture.

Before this is attempted, a brief discussion of shock in general is indicated. Moon<sup>56</sup> has expressed simply, a fundamental concept: "The shock syndrome results from a disparity between the volume of blood and the volume-capacity of the vascular system." The result of such a comparative decrease in the volume of blood is varying degrees of rapid weak pulse, low blood pressure, rapid shallow respiration, faintness and syncope, decreased temperature and pallor with clammy skin. The causes of such a syndrome are many and varied. Blalock<sup>57</sup> classifies shock: (1) hematogenic type, in which the initial and most important change is a decrease in the volume of blood, the simplest example being uncomplicated hemorrhage; (2) neurogenic type, in which the primary alteration is vasodilatation due to diminished constrictor tone, the result of influences acting through the nervous system; (3) vasogenic type, which is primarily vascular dilatation due to the action of various toxic agents directly on the vessels, illustrated by histamine shock; (4) cardiogenic type, in which, as rarely occurs, the primary disturbance is cardiac; and (5) unclassified conditions as loss of fluids from an exposed surface, profuse sweating or purging, etc.

For practical purposes the cardiogenic and unclassified conditions may be excluded from consideration as a cause of shock in cases of tubal rupture. There is, in all cases of tubal abortion or rupture, some loss of blood and no one will dispute that hematogenic shock exists to some degree at least. A neurogenic factor is possible in tubal rupture, since pain due to



peritoneal irritation by blood is usually present in lesser or greater degree. Since histamine and similar vasodilatory amines have been isolated from practically every tissue of the body<sup>58</sup> and appear to exist as a normal constituent of the wall, Guthrie<sup>59</sup> suggests that a vasogenic etiology for shock may be considered as a possibility in tubal abortion or rupture in which the fetal sac is extruded into the peritoneal cavity. These latter two factors, then, must be considered if blood loss is inadequate in any case to explain the degree of shock noted before operation.

In this series, sixteen cases were considered to present a clinical picture of more than mild shock. The degree was considered, after a study of the material presented in the chart, to be moderate in seven cases, moderate to marked in two cases, marked in three, and severe or extreme in four. Eleven of these were pathologic tubal rupture and five were cases of tubal abortion. Table VIII presents, on one side, the clinical evidence of shock, noting the presence of various symptoms and findings but not the degree, presents the preoperative blood pressure and pulse and an estimate of the degree of shock. On the other side is presented the degree of vaginal bleeding, its continuity and duration, and the surgeon's estimate of the blood in the peritoneal cavity, as well as the preoperative erythrocyte count and hemoglobin determination. In no patients in this series exhibiting shock was there found at operation a small amount of bleeding intra-abdominally. In all but two cases the description of the blood intraperitoneally was "large hemorrhage," "very large hemorrhage," or "abdomen full of blood." In the two cases in which the amount of blood was described as moderate, the description of the patient's condition preoperatively was such that the shock was classified as of moderate degree. Four cases were considered to be in severe shock. In three of these the operator stated the abdomen was "full of blood." In the

fourth case a "large hemorrhage" was present.

In general, the preoperative erythrocyte counts and hemoglobins were low enough to indicate severe loss of blood from the vascular system. It must be borne in mind, however, that in some patients operated on soon after a severe hemorrhage, both the picture of shock and the intraperitoneal hemorrhage are out of proportion to the red cell count and hemoglobin because sufficient time has not elapsed for dilution of the remaining cells in the vascular system. This was true in case 28 (Table VIII), which exhibited fairly severe shock with a large hemorrhage due to rupture two and one-half hours before admission and prompt operation. These findings are in accord with the statement of Falk<sup>32</sup> that it is usually in cases with rupture of the tube and sudden intraperitoneal hemorrhage that collapse is exhibited, and with the idea of Gordon<sup>40</sup> that "shock and hemorrhage are synonymous" and of Litzenberg<sup>15</sup> that the "shock" in ruptured ectopics is a disturbance in the circulation due to the loss of blood.

#### TREATMENT AND MORTALITY

A discussion of the treatment of eccyesis does not come within the scope of this paper, and only a brief résumé of the treatment of the cases in this series will be given. The seventy-three cases of tubal pregnancy in this group all came to surgery. In general, operation was performed as soon as the diagnosis was made. The primary operation was right salpingo-oöphorectomy in twenty-eight cases, right salpingectomy in ten, left salpingo-oöphorectomy in twenty-eight, and left salpingectomy in seven cases. In twenty-two cases only the primary operation was done, except for three preliminary curettements. In five cases in which the condition of the patient and the pathology present warranted it, secondary surgery was carried out. In thirteen cases this secondary procedure was appendectomy alone. In twenty-four cases the other tube or tube and ovary were



## Woodhouse—Tubal Pregnancy

TABLE VIII

MANIFESTATIONS OF SHOCK IN RELATION TO BLOOD LOSS

Case Number	Pathologic Diagnosis	Pallor	Faintness	Fainted	Poor Pulse Volume	Prostration	Blood Pressure	Pulse Rate	Temperature	Estimate of Shock	Vaginal Bleeding			Time of Vaginal Bleeding	Continuity of Vaginal Bleeding	Blood in Abdomen				Hbg. Per Cent
											Slight	Moderate	Profuse			Small	Moderate	Marked	Full	Red Blood Count
2	Rupture	Yes	Yes	No	?	No	112/72	118	?	Moderate	.....	Yes	At times	5 wks.	Continuous	.....	Yes	Yes	Yes	2,930,000
7	Rupture	Yes	Yes	Yes	Yes	No	?	128	?	Marked	.....	Yes	Yes	1 day	Continuous	.....	Yes	Yes	Yes	2,400,000
8	Rupture	Yes	Yes	Yes	Yes	Yes	104/70	148	?	Marked	.....	Yes	Yes	2 days	Continuous	.....	Yes	Yes	Yes	55
12	Abortion	Yes	Yes	?	?	No	108/?	102	98	Moderate	.....	Yes	Yes	10 days	Intermittent	.....	Yes	Yes	.....	55
13	Abortion	Yes	Yes	No	?	?	102/?	100	?	Moderate	.....	Yes	Yes	7 wks.	Continuous	.....	Yes	Yes	Yes	3,800,000
14	Abortion	?	Yes	Yes	Yes	No	82/50	144	99.6	Severe	.....	None	?	2 wks.	Continuous	.....	Yes	Yes	.....	52
19	Rupture	Yes	Yes	?	?	Yes	86/50	76	95	Severe	.....	Yes	?	5 wks.	Continuous	.....	Yes	Yes	.....	60
28	Rupture	Yes	Yes	?	?	No	105/65	94	98	Moderate to marked	.....	Yes	Yes	1 1/2 day	Continuous	.....	Yes	Yes	.....	50
31	Rupture	Yes	Yes	?	?	No	116/80	126	100	Moderate	.....	Yes	Yes	1 day	Continuous	.....	Yes	Yes	Yes	2,700,000
33	Rupture	Yes	Yes	?	?	?	84/38	130	98.6	Severe	.....	Yes	Yes	2 wks.	Continuous	.....	Yes	Yes	Yes	3,660,000
39	Rupture	Yes	Yes	Yes	Yes	Yes	100/60	140	98	Marked	.....	Yes	Yes	1 day	Continuous	.....	Yes	Yes	Yes	1,792,000
42	Abortion	Yes	Yes	Yes	?	No	?	?	99	Moderate	.....	Yes	Yes	1 1/2 day	Continuous	.....	Yes	Yes	Yes	2,880,000
50	Rupture	Yes	Yes	Yes	?	No	124/82	116	96	Moderate to marked	.....	Yes	Yes	1 day	Continuous	.....	Yes	Yes	Yes	3,060,000
57	Rupture	Yes	Yes	Yes	No	No	124/82	116	96	Moderate to marked	.....	Yes	Yes	1 day	Continuous	.....	Yes	Yes	Yes	2,400,000
61	Rupture	Yes	Yes	Yes	Yes	No	124/82	116	96	Moderate to marked	.....	Yes	Yes	1 day	Continuous	.....	Yes	Yes	Yes	2,400,000
65	Abortion	Yes	Yes	Yes	Yes	No	124/82	116	96	Moderate to marked	.....	Yes	Yes	1 day	Continuous	.....	Yes	Yes	Yes	2,400,000

removed with or without appendectomy and/or other procedures, including uterine suspension, myomectomy or, in two cases, hysterectomy. In the remaining fourteen cases secondary surgery included hysteropexy, colporrhaphy, trachelorrhaphy, with or without appendectomy.

The appendix was removed in thirty-seven or just over 50 per cent of the cases. Despite the theoretical danger of infection from secondary appendectomy, no evidence of morbidity was noted directly attributable to this cause. In general, blood clots were removed and intraperitoneal blood aspirated, since it was considered this led to a smoother convalescence. Autotransfusion was utilized in only one case; this patient survived, but the immediate postoperative course was stormy, due in part, it was felt, to the autotransfusion. The anesthetic used in seventy-two cases was ethylene and in one case, spinal. Ten patients were transfused postoperatively one or more times. The average transfusion was 400 c.c., but in one case, 820 c.c. was given at one time. Fluids by proctoclysis and subcutaneous and intravenous infusion were utilized freely and intravenous acacia was given during operation or immediately postoperatively in a number of cases.

These seventy-three patients were in the hospital an average of 18.4 days after operation. The average for those with tubal abortion and rupture was nineteen days and for those with an unruptured tubal gestation, sixteen days. The total period of hospitalization averaged somewhat more than this because of delay in arriving at a diagnosis in some instances. With the exception of secondary anemia, sixty-two patients had no postoperative complications. Of the remaining eleven (all cases of tubal abortion or rupture) one patient had a severe pyelitis, one a pulmonary embolus, one ran a febrile course due to an infected hematocele, one had bronchitis, one had an acute intestinal obstruction necessitating jejunostomy on the fifth postoperative day, three had ileus of a mild degree responding

to conservative measures, and two had wound infections.

One case terminated fatally on the third day. This patient, who had a tubal abortion, was returned from the operating room in good condition, but on the second postoperative day the pulse rose to 140 and subsequently became very weak and increasingly rapid, the respirations became shallow, face pale and then cyanotic. Death occurred about forty-eight hours after operation. Post-mortem examination revealed a large secondary intra-abdominal hemorrhage, apparently from the operative site, and pneumonia in both lower lobes. This constitutes a mortality of one in seventy-three consecutive cases, or a rate of 1.37 per cent for this series.

In Table ix are summarized the mortalities in a number of series of ectopic pregnancies reported during and since 1930. The composite mortality of 4.46 per cent for these 3,314 reported cases compares favorably with the composite series reported by McDonald<sup>61</sup> in 1923, 6,626 cases with a mortality of 7 per cent.

TABLE IX  
COMPARATIVE MORTALITY OF SERIES OF OVER FIFTY  
CASES REPORTED SINCE 1930

Author	No. of Cases	No. of Deaths	Mortality-Per Cent
Miller <sup>7</sup> .....	104	7	6.7
Von Graff and Brown <sup>8</sup> .....	153	3	1.96
Grier <sup>24</sup> .....	100	3	3.0
Brown <sup>23</sup> .....	62	1	1.8
Urdan <sup>4</sup> .....	474	14	2.95
Tyrone et al. <sup>41</sup> .....	309	36	11.6
Koster and Sheinfeld <sup>5</sup> .....	69	1	1.45
James and Lafferty <sup>6</sup> .....	103	3	2.91
Meagher <sup>60</sup> .....	247	8	3.2
Ludwig <sup>43</sup> .....	145	3	2.0
Scheffey et al. <sup>2</sup> .....	82	4	4.87*
Fitzgerald and Brewer <sup>33</sup> .....	500	39	7.8
Ricci and DiPalma <sup>45</sup> .....	100	9	9.0
Schumann <sup>8</sup> .....	307	8	2.6
Masson <sup>12</sup> .....	486	8	1.64*
This series.....	73	1	1.37
Composite.....	3,314	148	4.46

\* Two of deaths—unoperated cases.

## SUMMARY

This study is based on a review of available recent current literature and on data derived from seventy-three cases of tubal pregnancy treated on the surgical service of the Guthrie Clinic and Robert Packer Hospital over a period of years from June 30, 1927 to April 30, 1938.

A discussion of incidence, etiology and predisposing factors, and pathogenesis has been presented, based on both the conclusions of other authors and the data in this series.

Diagnosis is considered principally from the material in these seventy-three cases and a detailed analysis made of the symptoms and findings in these cases.

The shock syndrome is considered principally in relationship to its etiology in this series.

Finally, a brief résumé of the treatment utilized in this series is presented with the morbidity and mortality of the series. The mortality is compared with other reported series in the literature.

## CONCLUSIONS

The incidence of tubal pregnancy in this clinic was 1:58, which is not an accurate proportion between extra- and intra-uterine gestations in this community.

The idea that preëxisting tubal infection is an important cause of tubal pregnancy is borne out in this series. In 65.8 per cent of the cases a definite history or findings of pelvic inflammation were obtained. No data can be offered in support of or in disproof of endometrial tubal implants as an etiologic basis for tubal implantation.

There is no evidence in the literature or in these cases that race is a predisposing factor of any importance.

Tubal pregnancy may occur at any time during the child-bearing age. The decade of greatest incidence is between the ages of 25 and 35 years, including 52.1 per cent of the cases in this series.

The average marital period in these cases is 9.74 years, confirming the idea that tubal

pregnancy most frequently occurs following an extended period of marriage.

Of the cases in this series, 78.6 per cent had been previously pregnant an average of 2.82 times; 21.4 per cent were nulliparous.

In thirty-four cases in which the interval following the preceding pregnancy was noted, over 50 per cent of the patients had a secondary sterility of over three years.

Tubal pregnancy recurs in patients with a previous ectopic gestation more frequently than in the general group of child-bearing women. Recurrence in this series was 4 per cent, which is in agreement with the majority of figures presented in the literature.

After a careful classification of the cases in this series, the number of tubal abortions and of rupture was found to be the same, thirty-one cases of each. The least frequent finding at operation was an unruptured tubal gestation, 15 per cent in this series.

No appreciable difference was noted as to the tube involved, being in thirty-eight cases right side and in thirty-five cases the left side.

The diagnosis of tubal pregnancy is difficult and frequently missed. There was a diagnostic error in 32.8 per cent of these seventy-three cases.

Pain is the most constant symptom of tubal pregnancy, present in all but one case in this series. The type and character of pain is roughly an index to the existing pathology. Referred pain does not occur or is very infrequent in unruptured cases.

Amenorrhea was present in 56.7 per cent of this series, averaging twenty days. The average period of amenorrhea was longer by ten days in cases of tubal rupture than of tubal abortion.

Abnormal external bleeding occurred in 81.4 per cent of these cases, beginning an average of 23.5 days before operation and continuing as a more or less uninterrupted flow of small amount in the majority of cases.

Subjective symptoms of pregnancy were infrequent. Nausea and vomiting occurred

in forty-three of seventy-three cases but usually followed pain of some severity.

Symptoms and signs of syncope and shock were almost limited to cases in which tubal abortion or rupture was the finding.

The average blood pressure readings were lowest in cases of tubal rupture and essentially normal in unruptured cases. The converse was true in respect to the pulse rate.

Temperature readings vary considerably, depending on whether the patient is in severe shock or has had a recent hemorrhage. The temperature tends to rise moderately immediately following an intraperitoneal hemorrhage. This rise is usually not over 2 or 2½ degrees.

Abdominal tenderness is an almost constant finding in tubal pregnancy, specified as absent in only two unruptured cases and in one case of tubal abortion in this series. Tenderness is most frequently general across the lower abdomen in cases with intraperitoneal hemorrhage and localized to the quadrant involved in unruptured cases.

Rigidity was an infrequent finding in this series, present in only nine cases of tubal abortion and rupture. Distention of some degree was found in 20 per cent of the cases reviewed.

Cullen's sign is rarely seen; it was noted in one patient in this group.

Pelvic tenderness on bimanual examination was specified as absent in only one case. The tenderness was most marked throughout the pelvis in most cases of rupture and some of tubal abortion, whereas it was usually localized to the side involved in unruptured tubal pregnancy.

A mass was palpated in 68 per cent of the cases in which the pelvic examination was described, least often in cases of tubal rupture.

Forty-one per cent of this series showed softening of the cervix, enlargement of the uterus, or both.

The laboratory was of aid principally in the determination of leucocytes, the erythrocytic count and hemoglobin. The

Friedman test was positive in the six cases in which it was done in this series. Dilatation and curettage were used as a diagnostic procedure in ten cases in this series to advantage. There is little real contra-indication to its use.

No doubt there are occasional cases of ectopic pregnancy in which hemorrhage alone will not explain the shock manifested clinically, and in these cases a neurogenic or vasogenic explanation of the shock picture is necessary, but in this study there were no patients exhibiting marked or severe shock who did not have evidence of marked or severe intraperitoneal hemorrhage.

In this series of seventy-three cases, the mortality was 1.37 per cent, which compares favorably with other series reported in the literature.

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# NEWER ASPECTS IN THE TREATMENT OF VAGINITIS IN CHILDREN\*

ROSE H. ANDRÉ, M.D.

NEW YORK CITY

THIS is not an attempt to review the entire subject of vaginitis in children, but rather to point out a few important aspects in the examination and treatment of these cases. While marked progress has been made recently in this field, there is still a great diversity of opinion as to the site of infection, the duration of its contagiousness and the criteria of cure. The already large number of methods of treatment have lately been increased, which is evidence of the fact that no absolutely satisfactory method has yet been found.

In 1935, we reported on a very small group of cases (fourteen), including gonorrheal and nonspecific types, treated chiefly by theelin and fulguration. The results were fair; however, it was difficult to form a definite opinion as to the value of these methods. In May, 1938 we reported on a larger series (sixteen gonorrheal and 140 nonspecific cases), the specific cases being treated chiefly with larger doses of the estrogenic substance intramuscularly (average total dose 100,000 I.U.). One of the persistent cases with considerable cervical involvement was fulgurated through the Butterfield vaginoscope. Three of the series received a second course of injections, and one patient required a fourth course of treatment, in addition to two fulgurations. In general, the average length of treatment required for cure (that is, four negative smears and cultures) in this series was about six weeks. This group did not show the same rapid cures and results that other observers have obtained.

*Method of Examination.* In studying the cases in this clinic, the following routine has been adopted. After obtaining a careful history from the child's parent or guardian as to duration of condition, possible source

of infection, etc., inspection of the external parts is followed by the taking of cultures and smears (in that order). In the gonorrheal cases, where estrogenic substance is to be used, daily smears of the vaginal epithelium, according to the method of Papanicolau, are made *before, during and after* treatment.

The method of taking smears and cultures, we feel, is most important. It is done by means of a small curved glass urethral catheter (size 14 or smaller), with several small holes at its end, containing a few drops of sterile physiologic saline in the tip, in order to dilute the vaginal secretion. This catheter is passed well into the vagina and up to the cervix, held in place a moment, then rotated. The material is then immediately transplanted to blood and ascitic agar plates by the technician, who is always present in the clinic. In suspected gonorrheal cases or where there is a special indication, urethral and rectal smears and cultures are similarly taken. The advantages of this method over the cotton swab are obvious, since there is no breaking up of cells, smears can be made very thin and the process is much less painful even to infants.

*Method of Vaginoscopy.* Following external and bacteriologic examination, we proceed to the endoscopic examination. This is performed through the Butterfield vaginoscope, an instrument devised and constructed to permit direct visualization and treatment of the vagina and cervix in infants and children. It resembles in its construction the McCarthy cystoscope, except for its shorter length, a No. 18 French straight sheath with a working length of  $3\frac{1}{4}$  inches (desirable because it permits a larger field of view and closer

\* Presented before the Section of Genitourinary Surgery, New York Academy of Medicine, November 16, 1938.

approximation). It has a rubber disc, and irrigation is maintained through two stop-cocks. It can be adjusted to any universal

The instrument is carefully introduced after being tested and completely connected as to water and light. The coöperation of

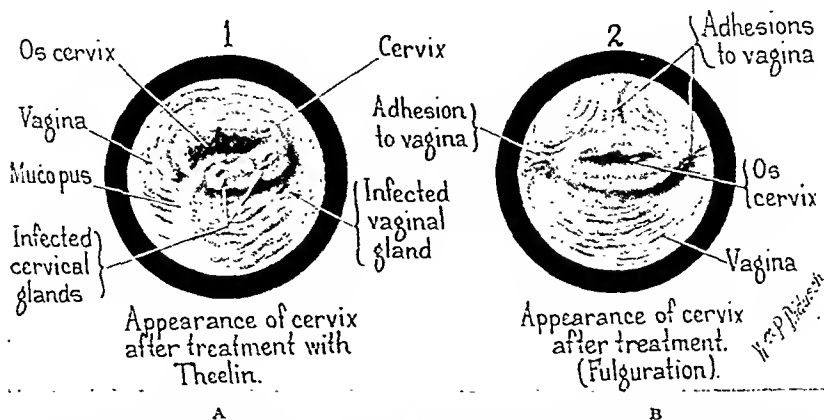


FIG. 1. Appearance of cervix and vagina in a 5 year old colored girl with chronic gonorrheal vaginitis and cervicitis. A, after treatment with theelin. B, after fulguration through vaginoscope.

light carrier. There is a single channel provided for an electrode. The technique for using this instrument is similar to that of any cystoscope or urethroscope. Its use is

the patient is secured where possible, by breathing through the mouth, etc. There appears to be no difficulty in making these vaginoscopic examinations, even in

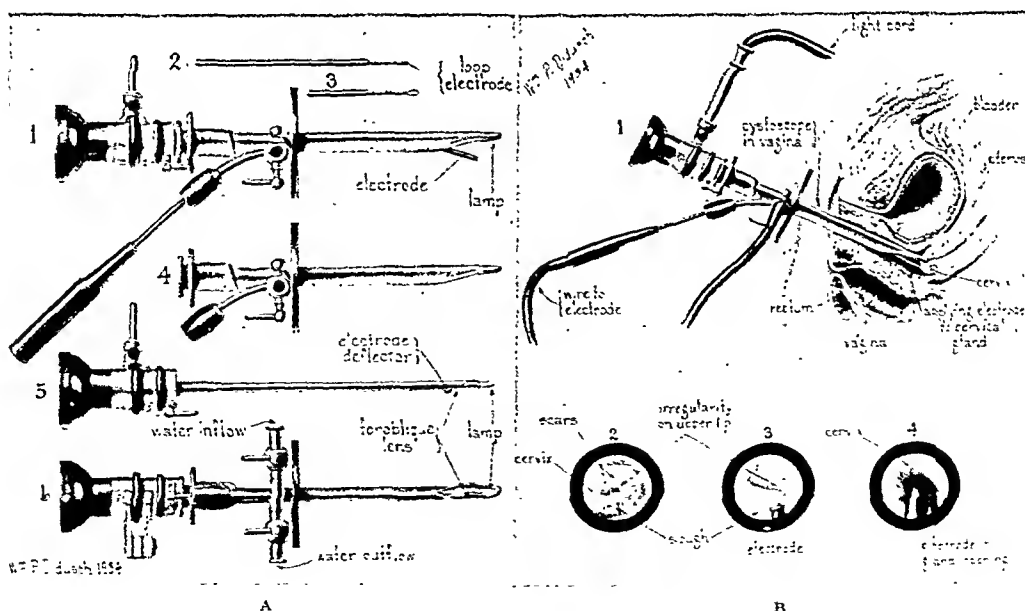


FIG. 2. A, Butterfield vaginoscope. B, vaginoscope in place.

twofold: (a) for examination of the vaginal mucous membrane, glands of the cervix and vagina; (b) for treatment of these infected glands, cysts and erosions.

the smallest infants (the youngest infant we examined was four weeks old). It is important for the observer to protect his eyes by wearing glasses.



We feel that the cervix should be examined in all cases when possible, as there is usually involvement of the vaginal portion in all acute infections. It is usually edematous, hyperemic with ectropion and erosions present. In the chronic stage, the cervix may be diffusely involved or there may be only small punctate hemorrhagic areas. Since cervicitis has been found to be one of the most common complications and causes of recurrence, we have included routine vaginoscopic examination as a part of every study. In this clinic from 1935 to 1938 the cervix and vagina have been examined routinely with no ill effects in 269 cases, of which twenty-five were gonococcal. This observation is of special value in cases which have relapsed and in those which fail to clear up readily.

**Further Routine Studies.** These include: examination of the pH of the vaginal secretions by the Nitrazene method, routine general physical examinations done regularly by the pediatrician, routine urine examinations (catheterized, when indicated), Wassermann and Kline tests, blood complement fixation. Such tests assist

doses continued over a long period. The dosage in these patients is best controlled by daily and weekly examination of the

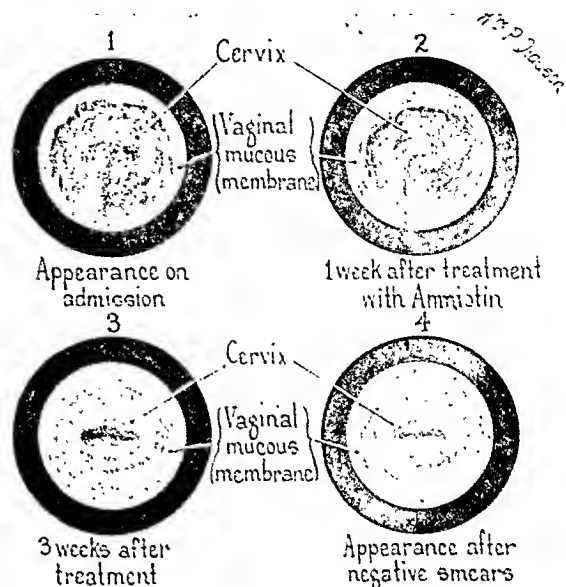


FIG. 3. Appearance of cervix and vagina in a 4 year old girl with acute gonorrheal vaginitis and cervicitis, before and after treatment with amniotin.

epithelial smears (Papanicolau), for evaluation as to cornification, leucocytes, types of cells, etc. *The nonspecific cases* are treated chiefly conservatively, according to

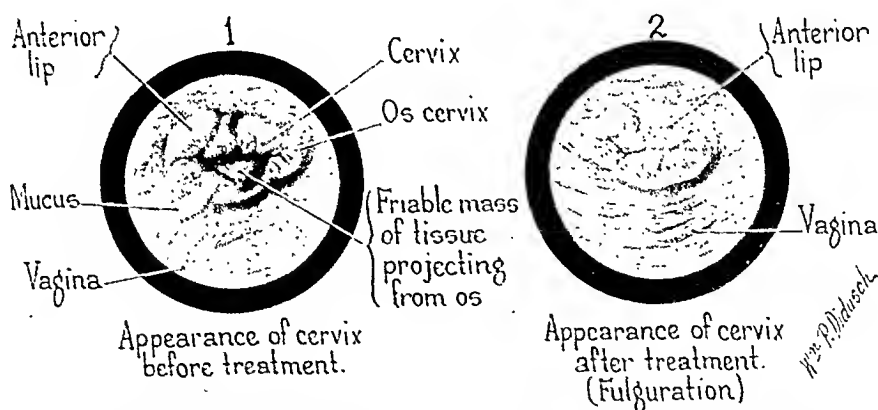


FIG. 4. Appearance of cervix in a 7 year old girl with chronic nonspecific vaginitis before and after fulguration through the vaginoscope.

greatly in completing the picture and should be a part of every case study.

**Treatment.** The present routine for the *specific cases* consists of estrogenic substance (chiefly amniotin), administered either by intramuscular injection, or vaginal suppositories, the best results being obtained by the injection method in larger

their etiology, bacteriology, etc. General treatment, with as little as possible locally (except external hygiene, sitz-baths, etc.) appears to take care of the great majority. Many cases are very mild, requiring little or no treatment. We feel that there may be a danger in over-treatment of these patients. The more severe of these cases are



treated as the gonorrheal group, nine having benefited by estrin therapy. Fulguration through the vaginoscope in the cases with cervical and glandular involvement of a chronic nature, seemed to be curative in several patients.

Observation at frequent regular intervals in all the cases treated in this clinic has proved to be a most important phase of treatment.

#### CONCLUSIONS

1. We emphasize the great necessity for earnest coöperation of all departments

concerned—the pediatrician, bacteriologist, histologist, endocrinologist, genitourologist, nurse, psychiatrist, social service department and the department of health—for the treatment of these cases.

2. We have shown a method for obtaining material for examination.

3. The method of endoscopic examination with the Butterfield instrument (vaginoscope) facilitates study and aids in the treatment of these children.

4. The best results in the specific cases have been obtained with estrogenic substance administered intramuscularly in large doses over a longer period.



#### CORRECTION

Dr. Samuel R. M. Reynolds, who wrote an article entitled "Gynecic Physiology and the Gynecologist," published in our April, 1940 issue, wishes to correct a statement made in that article. On page 179, second paragraph, starting on line seven-

teen, the sentence should have read "estradiol benzoate is about six times as potent as estrone in m.e.d., and it gives a much more prolonged response than the latter."

# VAGINAL HERNIA

ABRAHAM O. WILENSKY, M.D. AND PAUL A. KAUFMAN, M.D.

NEW YORK CITY

WHEN a rare condition can readily be confused with a very common one, an added trap is set for the unwary in the already complicated jungle of gynecological diagnosis. Posterior vaginal enterocele represents such a problem; for, were it not superficially similar to the universally familiar rectocele, it would be recognized far more often than it is in spite of its relative rarity. Its diagnosis is most often missed, as many a surgeon will admit, simply because it is not thought of. The rectocele which often accompanies a true vaginal hernia is then thought to be the only anatomic defect, with the result that the presence of the hernia is either unexpectedly discovered during the perineorrhaphy, or, perhaps, not recognized at all, resulting in an inevitable prompt post-operative "recurrence." For these reasons this communication is intended to direct attention to vaginal herniae and to review the accumulated experience regarding its diagnosis and treatment.

*Historical.* The first instance of vaginal hernia was recorded by de Garengot<sup>1</sup> in 1743. The second case was discovered by Sir Astley Cooper in 1804. Isolated case reports followed at infrequent intervals, the first case treated operatively being reported and the first review of the literature being made in 1885 by Thomas. More recently larger numbers of these cases have been recognized, so that by 1932 Bueermann<sup>3</sup> was able to collect a total of eighty-six cases after an exhaustive survey of the literature. Since then nine additional instances have been reported, which, together with our own case, bring the total up to ninety-six. Undoubtedly many cases have not been recognized; and, as more careful and accurate diagnoses are made, vaginal hernia will be found to be more prevalent than these figures would indicate.

*Anatomy.* Vaginal herniae are, anatomically, entirely concerned with the pelvic diaphragm which, as the floor of the abdominopelvic cavity, is called upon to sustain a large part of the weight of the abdominal viscera and to withstand the varying degrees of intra-abdominal pressure. This structure consists of the levator ani and coccygeus muscles with their enveloping layers of pelvic fascia. The pelvic fascia is a continuation of the transversalis fascia of the abdomen which descends into the pelvis as a single sheet down to the line of origin of the levator ani muscle from the anterior and lateral pelvic walls. At this level the pelvic fascia divides into two. The visceral layer, which proceeds over the superior surface of the levator ani muscles as the superior fascia of the pelvic diaphragm invests the various pelvic organs. The parietal layer descends further into the pelvis on the inner surface of the pelvic parietes. Immediately below the level of origin of the levator ani muscle the parietal layer of the pelvic fascia in turn divides into two diverging layers, the mesial portion proceeding under the inferior surface of the levator ani muscle as the ischiorectal fascia or the inferior fascia of the pelvic diaphragm, and the lateral portion continuing to line the pelvic cavity as the obturator fascia. It is thus seen that the pelvic diaphragm consists of a muscular layer sandwiched between two layers of fascia, blending in turn with the fascial envelopes of the three tubular structures which pierce it (i.e., urethra, vagina, and rectum).

At various regions there are localized thickenings of the visceral layer of the pelvic fascia which are designated as ligaments. Among the more important of such condensations are the sacrouterine ligaments, the transverse ligament of the

cervix, and the pubovesical ligaments. Blaisdell<sup>4</sup> has designated as the ligamenta plicovaginalia a condensation of the endopelvic fascia which curves downward from the sacrouterine ligaments on either side along the sides of the cul-de-sac of Douglas to end in the fascia of the vaginal vault.

**Classification.** Taken in its broadest sense, a hernia is an abnormal protrusion of any part of the body. While one usually associates the concept of an abdominal hernia with the presence of a peritoneal pouch or sac, a moment's reflection will bring to mind instances of extraperitoneal hernia of, for example, the bladder, in which no peritoneal sac may be present. Viewed in this light, the ordinary type of vaginal urethrocele, cystocele and rectocele may and should properly be termed extraperitoneal vaginal herniae. This was recognized by McGuire<sup>5</sup> who sought to emphasize the feature of a peritoneal sac in his case of vaginal hernia by calling it a "true" vaginal hernia. The latter designation, however, is not a happy one, because the extraperitoneal position of a protrusion does not make it any less "true" than one with a well formed peritoneal sac.

Young<sup>6</sup> used the term vaginal enterocele to point out by inference that the hernial protrusion included a peritoneal sac, for otherwise it could not contain loops of small bowel. This term is not sufficiently comprehensive, however, for undoubtedly many of these herniae contain omentum, ovaries, or other intraperitoneal structures not covered by the term enterocele. Phaneuf<sup>7</sup> has suggested the term hernia of the cul-de-sac of Douglas as perhaps the least misleading and most satisfactory one. It must, however, be noted that a hernia of the pouch of Douglas does not necessarily need to appear in the vagina but may bulge into the perineum as a perineal hernia or into the anterior rectal wall as a hedrocele. Furthermore this designation naturally does not include the anterior types of peritoneal vaginal hernia in which the vesicouterine rather than the recto-

uterine pouch participates in the formation of the hernial sac.

In view of these difficulties of nomenclature, the following classification of pelvic herniae is suggested as perhaps the most workable one:

A. Extraperitoneal vaginal herniae:

1. Urethrocele.
2. Cystocele.
3. Rectocele.

B. Peritoneal vaginal herniae:

1. Anterior.
2. Posterior.
3. Lateral anterior.
4. Lateral posterior.
5. Postoperative.

C. Perineal hernia.

D. Hedrocele.

E. Pudendal hernia.

F. Pelvic quasi-herniae:

1. Marked uterine prolapse.
2. Marked rectal prolapse.

Urethrocele, cystocele, and rectocele are too well known to warrant any further description here. An *anterior peritoneal vaginal hernia* presents in the midline of the anterior vaginal fornix, the peritoneal sac communicating directly with the vesicouterine pouch. The posterior peritoneal vaginal hernia which presents through the posterior vaginal fornix is the much commoner type, occurring about sixteen times as frequently as the anterior variety. Here the peritoneal pouch is either a direct prolongation of, or communicates with the cul-de-sac of Douglas. Lateral peritoneal vaginal herniae are quite rare, the only four recorded cases being reported by de Modena,<sup>8</sup> Etheridge,<sup>9</sup> Hansen,<sup>10</sup> and Thomas.<sup>2</sup> They enter the vagina through the lateral fornices and are subclassified as anterior or posterior depending upon whether their peritoneal openings are anterior or posterior to the broad ligaments. In the *postoperative types* the anatomic landmarks are usually distorted by a previous hysterectomy with a tendency toward fusion of what would otherwise have been purely anterior or posterior types.

*Perineal hernia* is closely related to posterior peritoneal vaginal hernia in that its peritoneal sac is also continuous with the pouch of Douglas. The fundus of the sac, however, dissects its way between the rectum and vagina to present as a bulge in the perineum rather than in the vagina itself. Moschcowitz<sup>11</sup> described the characteristics of this rare type of hernia in a review of twenty-five cases collected from the literature.

A *hedrocele* is likewise lined by a peritoneal sac continuous with the pouch of Douglas. In this type of hernia, however, the fundus of the sac neither prolapses into the vagina through the posterior vaginal wall nor does it dissect between the rectum and vagina to appear in the perineum. Instead it protrudes posteriorly through the anterior rectal wall to prolapse into the lumen of the rectum and at times to extrude through the anus itself as a polyp-like structure. The genetic relationships of posterior peritoneal vaginal hernia, perineal hernia, and hedrocele are apparent from a study of the accompanying diagrams and they are further emphasized by Zuckerkandl's<sup>12</sup> case which simultaneously or alternately presented the features of a posterior peritoneal vaginal hernia and a hedrocele.

*Pudendal hernia* is not a midline hernia. It is characterized by a peritoneal sac dissecting forward in the pelvis through a defect in the anterior portion of the pelvic diaphragm between the vagina and the ischium to present in the labium majus where it is covered laterally by the skin and medially by the vaginal mucous membrane. This condition is quite rare, only thirteen cases having been collected from the literature by Chase.<sup>13</sup> While the herniation has a vaginal aspect, it never prolapses into the lumen of the vagina and may not therefore be classified as a true vaginal hernia.

Extensive uterine and rectal prolapses are classified as quasi-herniae; for, while it is true that they are accompanied by a peritoneal pouch extending beyond the

normal confines of the body, this peritoneal participation is purely secondary to the extensive descent of the uterus or rectum. Furthermore the peritoneal outpouching is of a widespread character and may be more readily compared with the abdominal protrusion in diastasis recti than to an actual local herniation as in ventral hernia.

*Etiology.* A review of the reported cases of vaginal hernia reveals no significant clues as to its etiology on the basis of age distribution. The condition is found in practically every decade of life, most frequently, however, in early middle age. Congenital factors have been considered by Zuckerkandl<sup>12</sup> who made an extensive study of the development of the pouch of Douglas. According to this investigator the cul-de-sac normally extends down to the levatores ani in the fetus, its depth gradually decreasing from this time until puberty when it recedes to the level of the second or third sacral vertebra. Should this ascent of the Douglas not occur, an important congenital factor predisposing to a posterior peritoneal vaginal hernia becomes operative. Jones<sup>14</sup> also stresses this point, but states that in addition to the congenitally deep cul-de-sac there is another type of congenital defect in which there is a localized weakness or absence of the pelvic fascia allowing a small protrusion of a peritoneal sac below the level of an otherwise normally situated pouch of Douglas. This contention is supported by the occasional operative finding of a relatively small neck of the peritoneal sac at its point of communication with the pouch of Douglas rather than a direct wide continuation of the latter with the hernial sac proper. Dew<sup>15</sup> specifically mentions congenital absence or underdevelopment of the plicovaginal portion of the endopelvic fascia as a factor in the etiology of vaginal hernia.

The most important acquired factor which enters into the etiology of peritoneal vaginal hernia, is parity. This is not the only factor, however, as is demonstrated in the four cases reported by Bueermann<sup>3</sup> which

occurred in nulliparous women. Parity may cause (1) weakening of the pelvic fascia by the effect of prolonged labor, or by the

protrusion. Ascites by itself could scarcely be considered a direct cause of the hernia, however; otherwise it would be found far

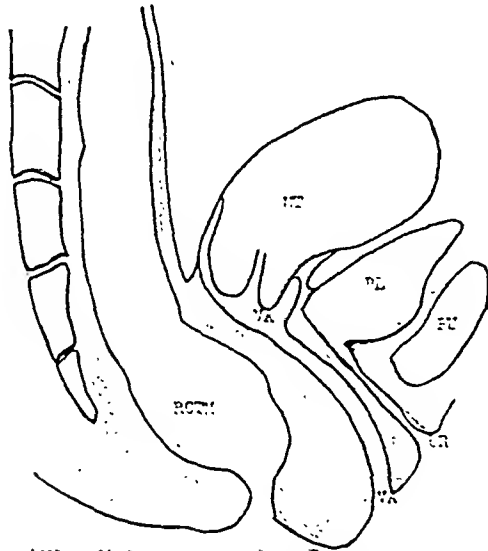


FIG. 1. Normal relations at female pelvic outlet. RCTM, rectum; UT, uterus; VA, vagina; BL, bladder; PU, pubis; UR, urethra.

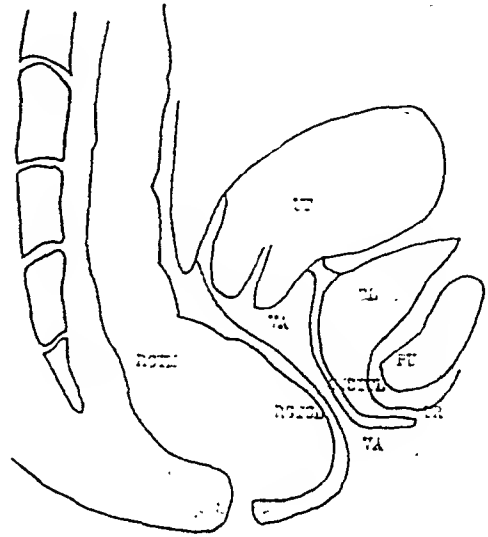


FIG. 2. Diagrammatic representation of cystocele and rectocele. RCTM, rectum; UT, uterus; VA, vagina; BL, bladder; PU, pubis; CYSTCL, cystocele; RCTCL, rectocele; UR, urethra.

subinvolution of the pelvic fascia following delivery; and (2) some subparietal laceration of the pelvic floor structure. In either case the fascial support at the bottom of the cul-de-sac becomes inadequate and the hernial protrusion of the peritoneum follows.

Huet<sup>16</sup> has suggested that uterine prolapse may cause peritoneal vaginal hernia by pulling down the peritoneum with it in its descent. In this type of case, if the prolapse is cured by operative measures, the peritoneal sac previously pulled down then remains as a peritoneal vaginal hernia. This may be so in those cases associated with uterine prolapse; but there are other instances on record in which there was no accompanying procidentia so that even the theoretical application of this hypothesis is extremely limited.

Sterns<sup>17</sup> and others have reported a few cases in which ascites was present in individuals with peritoneal vaginal hernia. They suggest that the weight of the peritoneal fluid is transmitted directly to the pouch of Douglas and in this way aggravates any previous congenital or acquired tendency toward the formation of a hernial

more frequently in view of the prevalence of ascites in portal cirrhosis, cardiac failure, nephrosis, peritoneal carcinomatosis, and in other conditions.

**Symptomatology and Diagnosis.** Peritoneal vaginal hernia comes to the attention of the patient as a painless reducible mass appearing in the vagina on straining. Frequently there is a history that the patient has undergone one or more vaginal operations for rectocele with a prompt "recurrence" of the protrusion. If untreated, the hernia becomes progressively larger, pushing its way through the introitus to appear as a globular mass between the thighs. In this location it naturally causes considerable discomfort and is accompanied by a varying amount of discharge when its mucosal covering becomes inflamed or ulcerated. The patient generally seeks relief before this stage is reached, although Phaneuf<sup>7</sup> has reported one case in which the vaginal hernia achieved the dimensions of a fetal head before operation was performed. Careful inspection of the mass occasionally reveals

the peristaltic waves of the contained loops of bowel. The hernia is generally spontaneously reducible with a characteristic gur-

cyst of the ampulla of Gartner's duct, which could likewise be reduced by pressure, the fluid returning along the duct to a

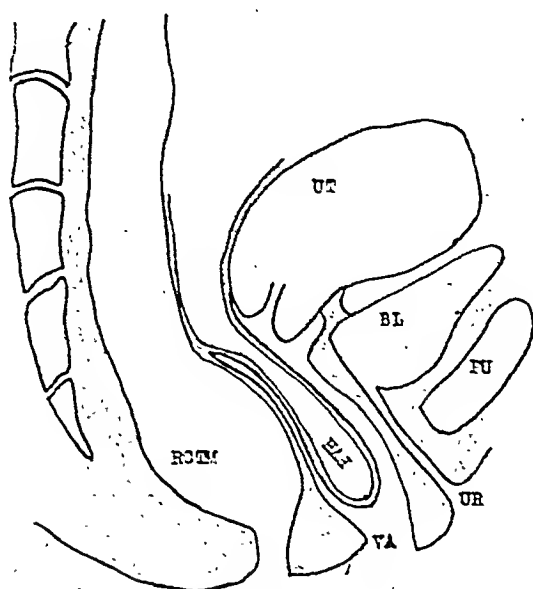


FIG. 3. Diagrammatic representation of posterior vaginal hernia. RCTM, rectum; UT, uterus; BL, bladder; PU, pubis; PVH, posterior vaginal hernia; VA, vagina.

gling sound when the patient reclines. Examination reveals a distinct hiatus in the pelvic fascia at the posterior, anterior or lateral vaginal fornix. A finger inserted into this ring easily detects a bulge and an impulse on coughing.

Large peritoneal vaginal herniae are relatively easy to diagnose, but it is the smaller posterior type which frequently escapes detection. Here the usual vaginal examination in the lithotomy position reveals a definite bulge of the posterior vaginal wall on straining closely resembling that of an ordinary rectocele. To make matters more difficult the latter frequently coexists. The differentiation is easily made, however, by the simple expedient of placing a finger in the rectum at the same time that the patient is straining. It then becomes apparent that the bulge of the posterior vaginal wall is not accompanied by a corresponding bulge of the anterior rectal wall as would be the case in an ordinary rectocele.

Miles<sup>18</sup> has pointed out that a peritoneal vaginal hernia could be confused with a

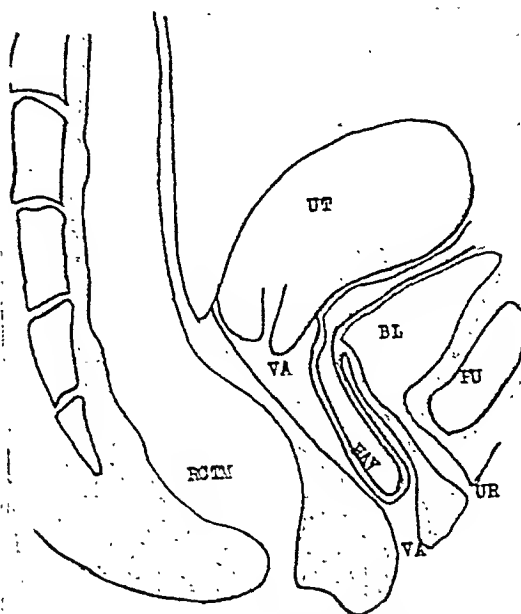


FIG. 4. Diagrammatic representation of anterior peritoneal vaginal hernia. RCTM, rectum; UT, uterus; VA, vagina; BL, bladder; PU, pubis; AVH, anterior vaginal hernia; UR, urethra; VA, vagina.

cyst of the parovarium in the broad ligament. Confusion with other conditions is more likely, though rare, when the hernia becomes incarcerated.

In Sweetser's<sup>19</sup> case the hernial sac contained a pint of serous fluid which was partially walled off above. Sweetser thought he was dealing with a cyst until laparotomy revealed the true nature of the condition.

Gunz<sup>20</sup> incised an inflamed vaginal hernia with fatal result while under the impression that it was an abscess.

Michelson and Lukin<sup>21</sup> cite a case in which a small vaginal hernia was mistaken for a uterine polyp. Removal of the "polyp" resulted in injury to contained bowel with prompt peritonitis and death.

Such gross errors of diagnosis are rarely made at present, however, the most common mistake being the failure to recognize the presence of the lesion altogether.

**Complications.** 1. *Incarceration.* Incarceration of a vaginal hernia is relatively rare due to the width of the sac at its neck.

The complication can, however, occur as is demonstrated by the following cases:

Barker's<sup>22</sup> patient was a woman who

early months of pregnancy, disappeared spontaneously in the later months only to reappear promptly after delivery.

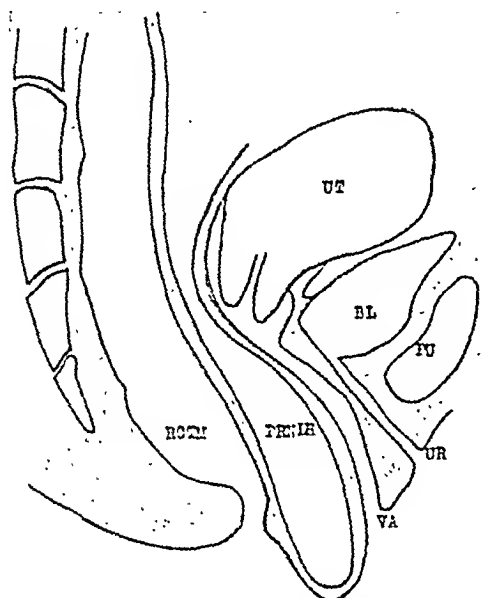


FIG. 5. Diagrammatic representation of perineal hernia. RCTM, rectum; UT, uterus; BL, bladder; PU, pubis; PRNLH, perineal hernia; UR, urethra; VA, vagina.

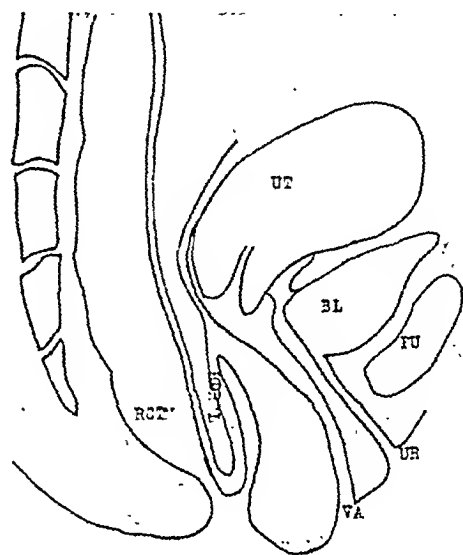


FIG. 6. Diagrammatic representation of hydrocele. RCTM, rectum; UT, uterus; BL, bladder; PU, pubis; HDRCL, hydrocele; UR, urethra; VA, vagina.

experienced recurrent attacks of intestinal colic associated with incarceration of a vaginal hernia. Symptoms were promptly relieved each time by manual reduction of the hernia.

In another case in Bueermann's series, incarceration resulted fatally.

**Incarceration during Labor.** Incarceration is more likely to occur during and to complicate labor, when the fetal head impinges upon the neck of the sac and prevents reduction of the hernia while the hernia in turn prevents further descent of the presenting part.

Barker treated such a condition by disengaging the head manually, reducing the hernia, and then allowing the head to reëngage, after which a normal delivery followed.

In Taylor's case, the vaginal hernia reduced itself spontaneously during labor, much to the relief of the obstetrician.

Rouville, Villa and Lafourcade<sup>24</sup> record a unique experience in a patient in whom a peritoneal vaginal hernia present in the

These investigators attributed this phenomenon to the increase in size of the uterus which, in rising out of the pelvis was more able to shield the pelvis from the intra-abdominal pressure. It is more likely, however, that the effect was produced by the pushing of the omentum and intestinal loops out of the pelvis so that, in the absence of free peritoneal fluid, there was nothing in the pelvis which could gain access to the hernial sac. Following delivery the omentum and intestines again descended into the pelvis with prompt reappearance of the hernia.

In addition to the incarcerated cases, the presence of the vaginal hernia acted as a complication in other cases of labor to produce dystocia of varying degrees. This occurred in ten of the fifty-nine cases reported by Bueermann.

2. *Rupture of a Vaginal Hernia with and without Evisceration.* The following rare accidents have been reported with vaginal hernia: (a) rupture of the hernial sac externally; (b) rupture of the hernial sac

externally with evisceration or prolapse of the hernial contents. These accidents invariably happen together so that they

with secondary shock and death. The post-mortem examination revealed a free perforation about 0.5 cm. in diameter in

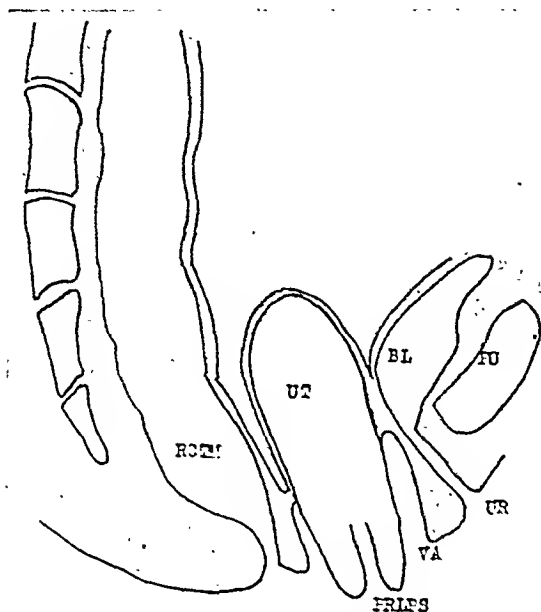


FIG. 7. Diagrammatic representation of pelvic quasi hernia due to extensive uterine prolapse. RCTM, rectum; UT, uterus; BL, bladder; PU, pubis; UR, urethra; VA, vagina; PRLPS, quasi hernia accompanying extensive uterine prolapse.

should be considered together. The accident has resulted following direct trauma and indirectly after straining, etc.

In Rieunau's<sup>25</sup> case evisceration occurred through the rupture of a peritoneal vaginal hernia. A prompt laparotomy resulted in a cure.

A third accident is: (c) subparietal rupture of the bowel contained in a vaginal hernia. Rupture of one or more intestinal loops within an intact vaginal hernia may result from either direct or indirect violence.

Huet<sup>16</sup> reports a case in which a direct injury to the hernia resulted in intestinal rupture with peritonitis and death.

Birchenall's<sup>26</sup> case occurred by indirect violence. The patient, a 63 year old woman with a vaginal hernia, experienced sudden severe abdominal pain, shock and vomiting on bending forward suddenly. Following recovery from the initial shock she felt well until the next day when a sudden adverse change in her condition occurred

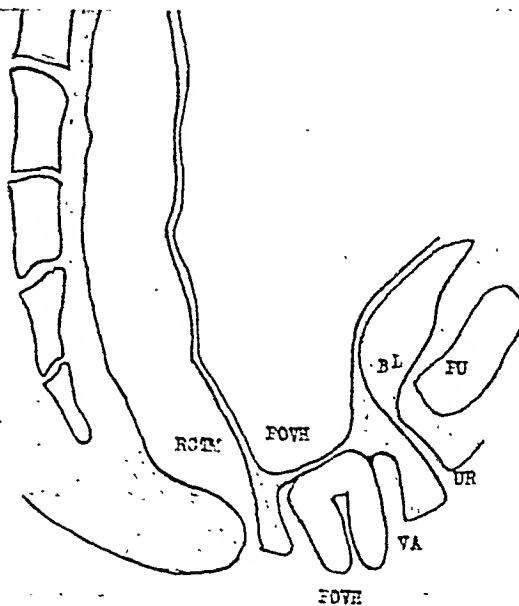


FIG. 8. Diagrammatic representation of postoperative peritoneal vaginal hernia. RCTM, rectum; POVH, postoperative vaginal hernia; BL, bladder; PU, pubis; UR, urethra; VA, vagina.

one of the loops of the ileum. Birschenall was unable to explain the mechanism of subparietal intestinal rupture at that time. Subsequent studies of intestinal rupture due to muscular effort<sup>27</sup> have demonstrated that the sudden increase in intra-abdominal pressure was responsible for a blowout of the intestinal loop lying opposite the neck of the hernial sac.

*Treatment.* It was realized very early that the treatment of peritoneal vaginal hernia could only be surgical. All attempts at control of the mass by the use of various pessaries were unsuccessful. Numerous ingenious operative procedures have been devised to cope with this condition and to this day there is still considerable diversity of opinion as to their relative merits. For the sake of clarity of exposition we have classified their operations into seven groups which will be described in turn.

1. *Elimination of the Peritoneal Sac by Turning It Inside Out by the Abdominal Route.* This was the first mode of surgical attack and was attempted in 1885 by



Thomas.<sup>2</sup> The condition, as demonstrated during the operation by Thomas, was an anterior vaginal hernia. A number of sutures were passed from the fundus of the hernial sac to the parital peritoneum of the anterior abdominal wall at a level which compelled the eversion of the sac when the sutures were tied.

Williamson's<sup>28</sup> case was a postoperative peritoneal vaginal hernia (following hysterectomy) in which the extreme form of vaginal hernia had resulted in an almost complete eversion of the vagina. Colpopexy was effected by passing a suture through the bottom of the peritoneal sac, through the submucosa of the vaginal vault and attaching it high up on the anterior abdominal wall. When tied, the stitch lifted up the vaginal vault and everted the peritoneal sac at the same time.

2. *Elimination of the Hernial Sac by Turning It Inside Out by the Vaginal Route.* Hundley<sup>29</sup> devised a vaginal operation based upon a similar principle which is even more ingenious. The patient had a posterior vaginal hernia combined with a uterine prolapse. The usual type of vaginal interposition operation was done as the first step in the operation. After the fundus of the uterus had been fixed anteriorly, the operator placed a finger in the vagina, reduced the posterior vaginal hernia, continued pushing the finger through the hernial ring in the posterior vaginal fornix and succeeded in turning the hernial sac inside out. By flexing the finger he then brought the bottom (apex) of the sac into the anterior peritoneal wound above the interposed uterus. The apex of the everted peritoneal sac was then sutured to the fundus of the uterus in its interposed position. This prevented the sac from returning to its original position. Following this the peritoneum was sutured in the usual manner and the anterior vaginal incision was closed.

3. *Elimination of the Hernia by Obliteration of the Peritoneal Sac by the Abdominal Route.* The operation, first devised by Marion,<sup>30</sup> was introduced in this country

by Moschcowitz.<sup>31</sup> It consists of a series of successive purse-string sutures passed within the boundaries of the pouch of Douglas starting at its bottom and reaching up to the level of the pelvic brim. By this simple expedient the rectum and uterus are brought in close apposition with consequent obliteration of the cul-de-sac and the hernial sac. Masson and Simon<sup>32</sup> have suggested that the sigmoid may also be utilized in the suture if necessary to cover a weak area in the reconstructed pelvic floor.

4. *Cure of an Anterior Vaginal Hernia by Vaginal Interposition.* In cases of anterior vaginal hernia the obliteration of the peritoneal sac may be accomplished by a vaginal interposition operation as suggested by Masson.<sup>33</sup> After this procedure is carried out the interposed fundus of the uterus fills the deepened vesicouterine pouch which had previously constituted the peritoneal sac. The interposition operation is carried out and concluded in the usual manner.

5. *Control of the Hernia by Occlusion of the Vagina.* In a selected group of senile patients in whom more radical methods appear contraindicated, Phaneuf<sup>7</sup> has secured good results by occluding the vagina by colpocleisis, using either the subtotal method of LeFort<sup>34</sup> or the total method of Dujarier and Larget.<sup>35</sup> The operation leaves the hernia itself untouched but prevents the further growth and further external prolapse of the hernia by occluding the vaginal canal. From a theoretical standpoint this procedure would seem inadequate but Phaneuf claims to have achieved eminently satisfactory results with it.

6. *Removal of the Hernial Sac by the Vaginal Route in Posterior Vaginal Herniae.* This operation is perhaps the one most frequently utilized today. According to Hartmann's<sup>36</sup> technique the sac is exposed by an incision through the posterior vaginal mucosa. The peritoneum is then opened and the intestinal loops packed away after which the sac is dissected up as high as possible and its neck closed by a purse-

string suture. The redundant portions of the sac are then ablated and the operation concluded by a high perineorrhaphy.

Black<sup>37</sup> has suggested that the stump of the hernial sac be anchored to the posterior wall of the uterus in order to secure a higher fixation. Ward<sup>38</sup> who has done much to popularize this operation in America, advises that it be combined with a Mayo vaginal hysterectomy as a prophylactic measure against the possible subsequent occurrence of a vaginal hernia when hysterectomy is performed for uterine prolapse. By approximation of the uterine ends of the broad ligaments and by removal of the pouch of Douglas as a potential hernial sac the possibility of postoperative peritoneal vaginal hernia is greatly minimized.

The vaginal operation has much in its favor in that it does not involve the operative shock and risks of a laparotomy. Furthermore it permits of an adequate repair of the perineum which the purely abdominal operations do not accomplish. However, one of the main reasons for the popularity of the vaginal approach is that a substantial number of the cases of peritoneal vaginal hernia are unrecognized as such prior to operation, the sac being accidentally discovered during the course of a "rectocele" repair. Under these circumstances conclusion of the herniorrhaphy by the vaginal route is to be considered the procedure of choice.

7. *Combined Abdominovaginal Procedure for Removal of the Sac and Repair of the Hernial Defect.* A study of the principles of hernioplasty in other parts of the body will reveal that all the successful operations attempt to effect a cure by the accomplishment of two objectives. One is to remove the peritoneal evagination constituting the hernial sac and the other to close the defect in the parietes which was responsible for the peritoneal protrusion in the first place. These fundamental principles should likewise be applied in the operative treatment of vaginal hernia. Lothrop<sup>39</sup> apparently had this in mind when he devised an operation

which, while unduly complicated and now obsolete, is worthy of mention here because it illustrates his attempt to comply with these two principles. After dividing the broad ligaments close to their uterine ends, he split the uterus in its frontal plane, removing the anterior half of that organ together with the uterine cavity. The peritoneal sac and the pouch of Douglas were then dissected out and the broad ligaments turned down and sutured across the defect in the pelvic floor. The posterior wall of the uterus was then turned back and sutured to the pelvic fascia at either side of the rectum. Finally the peritoneum was closed over both broad ligaments and uterus.

Today it is felt that such heroic but-tressing is unnecessary and that removal of the sac combined with adequate fascial closure is sufficient. This is fairly well accomplished by the vaginal operation described in the previous section but in the opinion of many surgeons a sufficiently high ligation of the sac cannot be accomplished through the vagina. Accordingly it has been suggested that a sufficiently high ligation be secured by the passage of a purse-string suture at the neck of the sac as visualized during a laparotomy. Following this the patient is placed in the lithotomy position and the sac again exposed through the posterior vaginal wall. Green and Buzzelle<sup>40</sup> have suggested that the sac be packed with gauze at the time of the laparotomy so as to facilitate its ready identification from below.

Ligation of the neck of the sac already having been accomplished from above, there is no danger of injury to the intestines nor of contamination of the general peritoneal cavity. Furthermore, the neck of the sac has been securely closed higher up under direct vision with less danger of inclusion of the ureters in the suture.

The operation is concluded by a high perineorrhaphy which will incidentally cure the frequently accompanying rectocele.

In our opinion the more radical anatomic restoration accomplished by the combined abdominovaginal operation justifies its

slightly greater risk over that of the purely vaginal procedure. In the case herewith reported a combined abdominal and vaginal operation was done in which added security against recurrence was obtained by including as one of the steps during the laparotomy and obliteration of the pelvic cavity by a series of superimposed purse-string sutures.

#### CASE REPORT

The patient is a woman 35 years of age who has borne one living child. In 1929 she was operated upon for a "protrusion" of the vaginal wall. A laceration of the cervix was repaired and a posterior colporrhaphy and perineorrhaphy was done. A recurrence of the condition then followed within a short time and by 1935 a marked vaginal prolapse was present. The patient was then operated upon again at which time a vaginal hysterectomy was done together with an anterior and posterior colporrhaphy and perineorrhaphy.

Again there was a recurrence of the "prolapse." In November, 1937, at the time the third operation (Wilensky) was done, there was a protrusion from the vagina which extended outwards between the labia for a distance of approximately 3 inches. The patient complained of the excessive annoyance which the protrusion caused, but the mucosa covering the latter was not eroded or ulcerated. Because of the characteristic history and physical findings, the diagnosis of vaginal hernia was made immediately.

Because of the nature of the previous operation, no distinction could be made between the anterior and posterior types of hernia, although from the history it cannot be doubted that originally the hernia was of the posterior variety.

The findings at operation were anatomically as follows: The hernial ring about  $1\frac{1}{2}$  inches in its largest diameter, was situated in the fornix just anterior to the rectum. The hernial sac was from 3 to 4 inches long. At the time of operation the hernial sac was empty. Abdominally, there were a moderate number of adhesions in the pelvis. The right ovary measured about 2 inches in its largest diameter and was occupied by a large number of encapsulated and other cystic formations. The right tube was essentially normal. The left tube and ovary were normal. The rest of the abdominal cavity was not explored.

The abdominal part of the operative procedure was as follows: A median subumbilical incision was made and the abdomen was explored as indicated above. Many adhesions were freed while exploration went on and the hernial ring was found, identified and cleared. The hernial protrusion was then evaginated upwards into the pelvic cavity. The peritoneal layer was dissected free from its underlying base after which the rest of the hernial protrusion was pushed back into the vagina. The hernial peritoneal sac was then obliterated by catgut sutures; the fascial margin of the hernial ring was tightly approximated and closed by sutures of chromicized catgut; and the closure was further protected by obliterating the pelvic cavity by a series of superimposed circular catgut sutures which took in the peritoneum and underlying pelvic fascia. The abdominal wound was then closed in layers in the usual way.

The vaginal part of the operative procedure was done as follows: The hernial protrusion was pulled downwards and outwards through the introitus and it was denuded of its mucous membrane on its anterior lateral and undersurface. The denudation was continued outwards to the perineal edge as in a rectocele and perineorrhaphy. The remaining layers of the hernial protrusion were divided longitudinally, exposing the vaginal side of the hernial ring. The latter was identified and the rectum was pushed away from it sufficiently to give room for a good suture. The hernial ring was then closed for a second time from the vaginal side by a purse-string suture of heavy chromicized catgut. The operation was completed as in a rectocele operation, the surplus portion of the remaining hernial protrusion being cut away.

The patient made an uneventful convalescence; healing took place throughout by primary union; the patient was discharged from the hospital well. A follow-up examination made six months later corroborated this opinion.

#### SUMMARY

1. Attention is directed to peritoneal vaginal hernia, a rare condition readily overlooked.

2. The classification of the condition and the theories regarding its etiology are discussed.

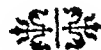
3. The ease of diagnosis once the condition is kept in mind and its differentiation from rectocele are emphasized.

4. The various operative procedures for the cure of this condition are reviewed.

5. A case report in which a cure was effected by a combined abdominovaginal operation is included.

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# THE CREEPING EPITHELIUM OF THE ANAL CANAL

JOSEPH KRAFKA, JR., M.D.

Professor of Microscopic Anatomy, University of Georgia School of Medicine

AUGUSTA, GEORGIA

THE anal canal and the rectum offer a wide variety of pathology including carcinoma, fistula-in-ano, fissures, hemorrhoids and pruritus ani. From time to time the same etiologic factors have been postulated to account for these various conditions since the theoretical premises for this zone are somewhat limited, being confined to embryologic considerations of a differentiation at a mucocutaneous junction, trauma and irritation dependent upon constipation, infection following diarrhea, local foci due to occlusion of the intramuscular glands by spastic sphincters, circulatory stasis or a neurogenic diathesis.

There are several reasons for this confusion in the interpretation of causal factors. First of all, courses in histology and pathology give too little attention to this zone. Practically the only figures given in the various textbooks of histology are copied from the work of Johnson of the anal canal of a 187 mm. fetus. Pathologists are forced to neglect this region in routine autopsies because of the technical difficulties involved in its resection. The proctologist, with the viewpoint of a specialist, depends primarily on the macroscopic appearance and has his own pet theory of etiology. Proctologists are not even in agreement as to the gross anatomy of the canal, nor a definition of the White Line of Hilton (Hiller, 1935; Stroud, 1896). Hence we may safely say that the *normal rectum of the adult* is still unknown.

Two excellent papers have been written on the embryology of the anal canal, namely those of Johnson (1914) and Tench (1937). For the various opinions on the relationship of normal structures to the various pathological conditions, the reader is referred to the articles of Bacon (1932),

Tucker and Helwig (1933), Pope (1932), Milligan and Morgan (1934), Rankin et al. (1934), and Hiller (1931). The purpose of the present paper is to stimulate interest in the normal histology of this zone and to advance a new hypothesis which seems successfully to correlate the majority of miscellaneous facts which have heretofore lead to so much confusion.

That there is a marked variability in the character of the epithelium in the different zones of the anal canal is admitted by all. Johnson has reviewed the subject and according to Braun's table, simple columnar epithelium is found on the proximal parts of Morgagni's columns, in the sinuses, in the crypts of Lieberkühn and in the blind ends of the sinus diverticulæ. Stratified columnar epithelium is found in the distal parts of the sinuses, on the distal borders of the columns, in the secondary sinuses and their diverticulæ. Stratified cuboidal epithelium of a polyhedral variety exists on the summits of the columns in the distal parts. To this list Johnson adds stratified cuboidal in the larger ducts of the intramuscular glands and simple columnar in the branches of these glands. A transitional line extends upwards from the zona intermedia to the zona columnaris following the bases of the rectal columns to form the zigzag line or *linea sinuosa analis*.

This whole zone is of course in continuity with the true cornified stratified squamous epithelium of the *zona cutanei* or true skin of the anal region.

The majority of proctologists consider the proctoderm to have fused with the hind gut at the base of the pectinate line or the serrated margin bearing the anal papillæ, just below the bases of the columns of Morgagni. This would make the entire *zona intermedia* of ectodermal origin.

Johnson (1914) has carefully reconstructed the proctodeum and the anal plate and the ampulla of the rectum and has followed the

at their bases. My own observations on a number of human fetuses support this view. The process of inward extension of



FIG. 1. Photomicrograph of section of the rectum of female age 38. Autopsy. Note pseudogland formation and superficial stratified epithelium dipping into the crypts of Lieberkühn to replace their simple epithelium. Longi section.

progressive development of the definitive canal from its primary sources. He claims that both the zona columnaris and the zona intermedia are of ectodermal origin, since the bulbus analis and the bulbus terminalis both lie above the original anal plate. Tench (1937), however, is not in full agreement.

On either point of view, a modification of the original single cell layer of the columnar zone is established, since a stratified columnar or a stratified squamous epithelium is commonly seen on the matured columns of Morgagni, which lie definitely above the pectinate line. Johnson's figures show a definite chronological order in this process of stratification with age. The process begins distally and extends inward. It varies locally, being more advanced on the exposed surfaces of the columns and somewhat retarded in the furrows and ampullae. The studies of Bacon (1932) on stillborn fetuses bear this out. Simple columnar epithelium may be present on the tips of the columns and stratified squamous

stratified squamous epithelium is not peculiar to the anal canal. It occurs first of all when the oral membrane is perforated, connecting the stomodeum with the foregut. Stratification extends inward through the mouth, pharynx and esophagus to stop abruptly at the cardia with a microscopic transitional zone continuous with the columnar epithelium of the stomach. In the vaginal canal, the stratified squamous epithelium stops abruptly at the external os of the cervix unless imperforate hymen persists. With age, pregnancy and infection, the stratified squamous epithelium continues to migrate inward at the expense of the columnar, as a *creeping epithelium* blocking the cervical glands to produce the follicles of Naboth.

As a working hypothesis, the view was adopted that the extension of stratified squamous epithelium inward in the anal canal was not limited to the fetal period and hence that the squamous border might well extend beyond the anorectal line with advance in age. On this basis, material was

obtained from the cadavers in the Anatomy Hall, from autopsies by the Department of Pathology, and from stillborn fetuses.

A female (at autopsy), age 38 (Fig. 1), presented a beautiful example of pseudogland formation at the anorectal junction. Note the



FIG. 2. Photomicrograph of section from cadaver (female, age 43). Note the stratified squamous epithelium resting on tall papillae immediately approximate to the crypts of Lieberkühn. Longi section.

Material was fixed in formalin, sectioned in paraffin and stained with hematoxylin and eosin. It included longitudinal sections from four fetuses, eleven autopsies and seven cadavers, with the oldest specimen aged 67 years.

For the ages 3 months, 15 months and 3 years, the pathologist cut the specimen above the anorectal line and hence the junction was not shown. Autolysis was marked in the preparations from the 13 and 8 year old specimens, but the stratified squamous epithelium could be recognized at the level of the first crypts of Lieberkühn. Cadavers #457, Dickens, Peters, Lanier, were discarded. Sections showed that the block was taken below the junction, an error easily made because of the heavy cotton bolus which is commonly inserted in the rectum by the mortician. The nine remaining specimens were well fixed and show definitely that the stratified squamous epithelium does continue to extend upward in the anal canal and that it does block the crypts of Lieberkühn.

superficial stratified columnar epithelium dipping in from the surface to replace the simple columnar epithelium of the crypts of Lieberkühn.

The cadaver of a female, age 43 (Fig. 2), showed thick, stratified squamous epithelium, resting on tall papillae and immediately proximate to the crypts of Lieberkühn. Goblet cells were well preserved in the latter.

In a male, age 44 (Fig. 3), the specimen was not so well preserved at autopsy as the two previous, but the sections showed clearly that the stratified squamous epithelium had extended upward beyond the first crypts of Lieberkühn.

Male, age 49, autopsy specimen. While the preparation had undergone some autolysis, the section again showed definitely that the stratified squamous epithelium had extended upward to the anorectal line.

Female, age 54, autopsy. (Figs. 4 and 5.) This preparation showed a fine example of the extension of the stratified squamous epithelium beyond the first rectal glands. In Figure 4 these glands are readily distinguishable from the ducts of the so-called intermuscular glands which branch off the anal crypts of Horner, seen in the lower half of the section. That the



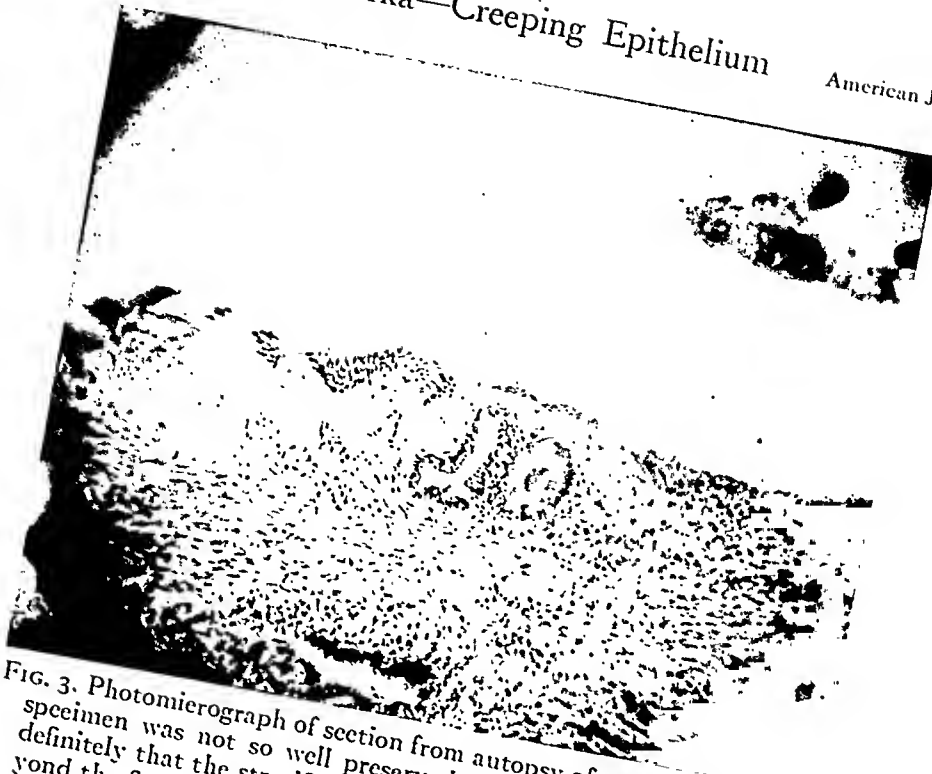


FIG. 3. Photomicrograph of section from autopsy of male, age 44. This specimen was not so well preserved as the other two but shows definitely that the stratified squamous epithelium has extended beyond the first crypts of Lieberkühn. Longi section.

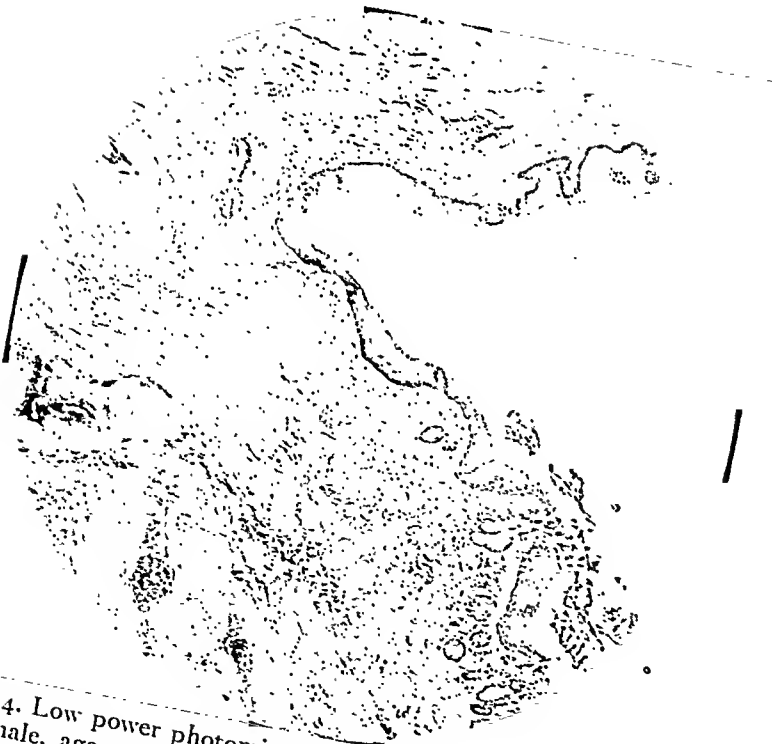


FIG. 4. Low power photomicrograph. Section from autopsy of female, age 54. Note the extent of the stratified squamous epithelium, up to and beyond the anorectal line. That these blocked glands are not the so-called intramuseular glands or diverticulae is clear, since the duct of the latter appears opposite the ampulla. Note that the blocked gland is assuming a branched character unusual for the crypts of the large intestine.



epithelium is squamous and not cuboidal, prismatic or columnar is evident in Figure 5.

Female, age 58, a cadaver (Fig. 6), again

review current opinion as to the various etiologic factors in this zone. Pope, believes that the anorectal line is definitely pre-

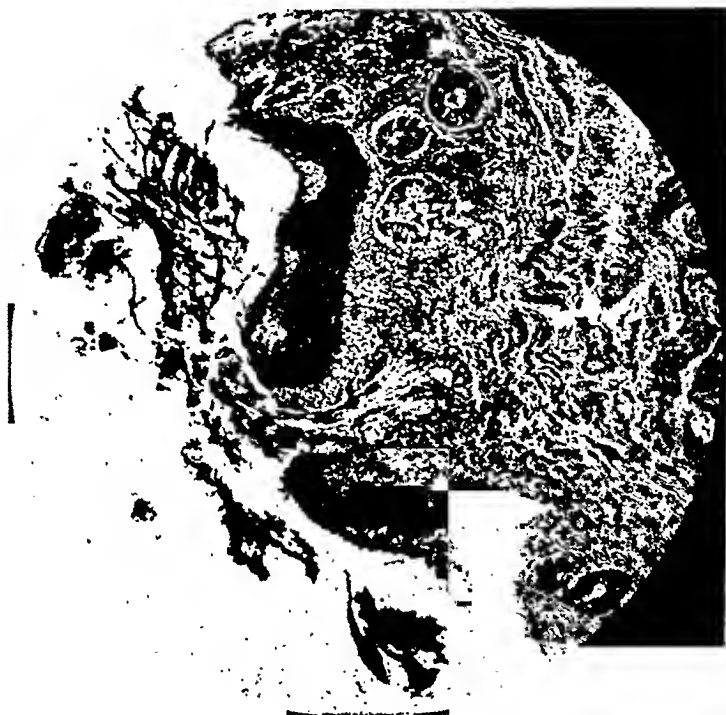


FIG. 5. Same section as Figure 4 under a higher magnification.

showed definitely the extension of stratified squamous epithelium up to and beyond the first crypts of Lieberkühn.

Male, age 67, at autopsy showed definite pseudogland formation just below the first crypts of Lieberkühn, and stratification of the ducts of the intramuscular glands.

A female cadaver, age 24, showed pseudogland formation and encroachment in evidence.

Another cadaver, female, age 36, was strikingly similar to Figure 3. One crypt of Lieberkühn lay below the level of the stratified columnar epithelium. One gland was definitely blocked and cystic. In the transition zone there appeared a number of hyaline plugs that gave the appearance of atrophic crypts of Lieberkühn. This suggests the method by which the anorectal line may retreat inwards.

#### DISCUSSION

The foregoing preparations leave no doubt that there is a *creeping epithelium* in the anal canal. The significance of this process as an etiologic factor in the production of common pathology of the rectum may next be considered. But first, we may

disposing to cancer; polyp formation due to chronic irritation may form the basis for malignancies. Linder and Wood, claim that melanomas may begin as displaced pigment cells, 1 to 2.5 cm. above the anal canal. Phifer, reviewing rectal cancer in childhood, postulates a beginning on the basis of trauma due to fecal stagnation. He cites Weinlesner's hypothesis that the growth of cancer in the rectum of adolescents is associated with the rapid growth of adenoid tissue at this time. Martin, discards the hereditary factor and considers polypi as most predisposing. He discusses Rossir's correlations with fistulae, hemorrhoids, cryptitis and excludes the anal region because only 2 per cent of the cancers of the rectum occur in the anal canal. Goforth, premises a metaplasia of gland epithelium to account for the occurrence of squamous cells at high levels, but questions the origin of a malignancy in any type of preëxisting lesion such as ulcerative colitis or diverticulitis.

In development, Rankin believes that the crypts are due to the purse-string effects of the sphincters and that cryptitis

without symptoms in the early stages. Extension may occur by direct growth, by venous invasion or by lymphatic invasion.



FIG. 6. Photomicrograph of section from cadaver of female, age 58. Note again the extension of the stratified squamous epithelium up to and beyond the mouth of the first crypt of Lieberkühn, and the branching character of the glands.

and papillitis are due to constipation, diarrhea, straining and infection.

Fistula-in-ano follows infection of ampullae, and their associated intermuscular glands, due to block following a spastic sphincter, and extending into the perivascular spaces. Hayes and Burr, 1936, cite one case of an epithelioma arising in a fissure, which was discovered accidentally.

Since the proctologists lay claim that 10 per cent of all cancers and 96 per cent of all intestinal cancers occur in the large intestine and rectum, the problem is significant. Manning, 1937, points out that the commonest site in the rectum is on the dorsal wall. If this is the case, two hypotheses offer themselves to account for the frequency, namely (1) cell rests from the remnant of the tail gut; (2) "organizer diffusion" from the dorsal lip of the blastopore.

But a third hypothesis, correlated with the general factor of creeping epithelium is also rational. Brindley, 1932, states that malignancies of the rectum are singularly

We offer the suggestion that gland block due to overgrowth of ducts by the squamous epithelium may be the source of the invasive cells, since the majority of malignancies are adenocarcinomas of the cylindrical cell variety belonging to the crypts of Lieberkühn. In Figures 4 and 6, duplication of crypts is seen, suggesting an initial step in adenoma production. This hypothesis is advanced on the basis of similar behavior of the squamous cells of the uterovaginal junction. Most of the pathology of the cervix is thought to arise in this "battle-ground" of cell differentiation (Schiller, 1936) with infection, trauma, erosion and the endocrines playing secondary rôles to the developmental process of squamous cell overgrowth or "creeping epithelium." Here, as in the anal canal, occur cystic glands, local foci of infection, fissures, papillomatous growths and malignancies. And in each case it is rational to suppose that a vicious circle of events exists which in one instance produces one

type of pathology, in another instance a more malignant type. It is hoped that by directing the attention of both gynecologist and proctologist to the similarity in the two areas that an evaluation of the respective etiologic factors may be made more specific.

#### CONCLUSIONS

1. The anal canals of eighteen humans have been sectioned longitudinally and the preparations studied.

2. Satisfactory preparations for ages 8 and 13 show stratified squamous epithelium at the anorectal junction.

3. From ages 38 to 67, the anorectal junction is characterized by pseudogland formation, duct overgrowth, cyst formation due to a creeping epithelium.

4. Theories of the etiology of the various pathologic conditions in the rectum are

discussed and related to the factors produced by creeping epithelium.

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# CHLOROPHYLL—ITS THERAPEUTIC PLACE IN ACUTE AND SUPPURATIVE DISEASE

## PRELIMINARY REPORT OF CLINICAL USE AND RATIONALE\*

BENJAMIN GRUSKIN, M.D.

Director of Experimental Pathology and Oncology, Temple University

PHILADELPHIA, PENNSYLVANIA

THE history of modern medicine as contrasted to that of even comparatively recent times might well be considered the story of man's fight against infection. Since the time of Koch, Pasteur, Klebs, Loeffler and a score of other investigators scarcely more than half a century ago, methods designed to prevent or cure bacterial infections have followed two major lines of investigation: first, that of antisepsis (disinfection), or the destruction of bacteria by chemical means; and second, the immunologic approach by which the individual's resistance against infection has been developed by the introduction into the host of antigenic substances, designed either to stimulate such antibody formation or to neutralize the toxic products of the bacteria.

In the field of chemotherapy, a large number of antiseptic agents has been employed with varying degrees of success. The great objection to the majority of these substances has been their irritating and toxic effects, even to the point of actual tissue destruction as well as the destruction of the infectious agent. Comparatively few of these substances have been utilizable except in topical, local application in concentration enough to be effective as bactericidal agents. On the other hand, the specific biologic products, while of inestimable value in many cases, likewise have but a limited and restricted field. Furthermore, in the majority of instances, their action is so slow in developing to an effective degree that they lose much of their practical application.

For this reason, the use of chlorophyll in the treatment of infections, particularly in local suppurative lesions, either of an acute or chronic nature, represents a new approach to the treatment of such conditions, combining as it does a background of chemotherapy with what we believe a much broader biological method. It is the purpose of this paper to review some 1,200 cases of widely diverse character, ranging from acute infections of the upper respiratory tract and accessory sinuses to chronic ulcerative lesions of various types associated especially with varices, sinuses and fistulae. A consideration of the mechanism by which these clinical results have been obtained seems worth exploring from the theoretical standpoint.

### THEORETICAL CONSIDERATIONS

It is interesting to try to explain the mechanism of the action of chlorophyll in suppurative processes. At the present time, much of this explanation must of necessity be of a theoretical nature since it is not possible with our present methods adequately to supply the necessary experimental data. It is suggested that the action of chlorophyll consists for the most part of increasing the resistance of cells in some physicochemical manner so that enzymic digestion of the cell membrane by invading bacteria or their toxins is checked. As a corollary to this it is suggested further that the bacteria are likewise inhibited from forming toxic compounds. Haas<sup>1</sup> and others have recently emphasized the importance of the so-called "intercellular phase"

\* Detailed case reports will be included in the author's reprint.

in tissue metabolism. They have been especially interested in the exchange of lipoids in this intercellular matrix. It is assumed, in line with this theory of Haas, that chlorophyll acts similarly on this intercellular matrix. This is evidenced by its stimulating effect upon the growth of the supportive connective tissue cells and the development of granulation tissue. Similarly, because of this cell activity, it seems logical to believe that there develops an effective barrier to bacterial invasion. By the same reasoning, it is probable that the metaboloids of these cells likewise may be altered to a less toxic form before they are absorbed and pass into the body economy.

Chlorophyll further has to a certain degree an indirect action on bacteria as judged by the clinical response in anaerobic infections. Due to the nature of such bacteria, the lesions are usually extremely foul smelling. Almost invariably this odor disappears after a few applications of the chlorophyll preparation. This may well be explained on the basis that chlorophyll, having the property of breaking down carbon dioxide and thus setting free oxygen, tends to inhibit the action of such anaerobic bacteria. It is possible, further, that bacteria being of vegetable origin, yet possessing ordinarily no chlorophyll, undergo some biological change in the presence of this substance.

In vitro experiments do not show that chlorophyll itself has any definite bactericidal effect, but it does seem to possess some slight bacteriostatic property. Thus, the clinical results which are obtained with the use of this agent may be explained as a highly complex process depending in part upon a more or less direct action on the organisms themselves, on a stimulating effect upon the supportive tissues, and upon some alteration of cell metabolism through the creation of adverse environmental conditions during the intercellular phase of metabolism.

Among other theoretical considerations which should be mentioned in respect to

the possible effect of chlorophyll, is that on the production of fibrolysin. In accordance with the theory of Tillett and Garner,<sup>2,3</sup> who have shown that the production of fibrolysin is a very significant factor in *Streptococcus hemolyticus* infections, and with the work of Reiner, who reports that many of the pathogenic bacteria will produce fibrolysin, the suggestion is made that this function of bacterial activity is neutralized either directly or through some counteracting effect on the part of the newly formed connective tissue cells. On the basis of these observations, the theoretical application of chlorophyll in the treatment of infection becomes much wider, in that specificity of bacteria does not play any part, as is usually the case. It is for this reason that we believe it occupies a position of biologic significance in the therapeutic field, and may prove to be of even greater importance than our preliminary observations, which are being reported here, suggest.

In connection with the use of chlorophyll, it is interesting to note that in cases of ulcerative carcinoma where a great deal of putrefaction with associated foul odor exists (obviously the result of secondary bacterial infection and proteolysis), the use of chlorophyll tends to clear up this foul odor rather promptly. It, furthermore, helps stimulate the production of the connective tissue, and in this way may even be of value in the treatment of such lesions so far as limiting their growth locally may be concerned. Work in this field has only recently been attempted, but is being pursued and will be reported at a future time.

Chlorophyll has a further advantage in that it is nontoxic. It may be introduced intravenously, or may be taken orally, in relatively large amounts without harm to the patient, although to date its usefulness by these routes in infections is not particularly promising, as might be anticipated from its theoretical action on the tissues locally.

## CHEMISTRY

This paper is primarily devoted to a consideration of the therapeutic application of chlorophyll and only brief mention of its chemistry will be given. Chlorophyll is the green coloring matter of plants and is present in all growing vegetable cells. The chloroplasts of the plants consist of a colloidal mixture of proteins and other substances, with four pigments, namely: chlorophyll A ( $C_{55}H_{72}O_5N_4Mg$ ), chlorophyll B ( $C_{55}H_{70}O_6N_4Mg$ ), carotene ( $C_{40}H_{56}$ ), and xanthophyll ( $C_{40}H_{56}O_2$ ). It is known that the photosynthesis of starch from  $CO_2$  does not proceed in the absence of chlorophyll. Our present knowledge of the chemistry of chlorophyll is chiefly due to the work of Willstätter.<sup>4</sup>

The chlorophyll employed in this work was in the form of the water soluble derivatives of chlorophyll, namely: sodium magnesium chlorophyllin ( $C_{34}H_{31}O_6N_4MgNa$ ), sodium iron chlorophyllin ( $C_{34}H_{31}O_6N_4FeNa_3$ ), sodium copper chlorophyllin ( $C_{34}H_{31}O_6N_4CuNa_3$ ), also the oil soluble chlorophyll A ( $C_{55}H_{72}O_5N_4Mg$ ) and chlorophyll B ( $C_{55}H_{70}O_6N_4Mg$ ). The oil soluble chlorophyll was employed in the preparation of ointments and suppositories only, and the water soluble chlorophylls were used in the preparation of solutions.

## METHODS OF USE

From the foregoing discussion concerning the theoretical mechanism of chlorophyll, it becomes apparent that whatever technique is used should be designed so that the chlorophyll will come directly in contact with the tissues involved in the pathologic process. This is to permit the diffusion of the agent into the intercellular matrix where it is believed that reaction occurs. Special care must be taken in cases where there is deep ulceration with undermined edges and in racemose fistulous and sinus tracts to make sure that the chlorophyll reaches all parts of the wound. If this is not accomplished, it has been found that the chlorophyll tends to stimulate granula-

tion tissue formation superficially, closing off the deeper infected areas. In such cases it has been necessary to break through this superficial repair tissue and reapply the chlorophyll to the deeper structures. This is in line with the usual surgical principle that all infected wounds should heal from the base.

In outlining the technique of administering chlorophyll in varying conditions, we gratefully acknowledge the assistance of several of the members of the Temple University Hospital Staff, especially that of Dr. J. Norman Coombs, Associate Professor of Surgery, for its application in various surgical problems, and that of Drs. Robert F. Ridpath and T. Carroll Davis, Professor and Assistant Professor respectively of Laryngology and Rhinology, in relation to otorhinolaryngologic disease.

Dr. Coombs has been kind enough to permit us to quote him in regard to his results in the use of chlorophyll in surgical infections. He notes that "there are two major types of lesion in which chlorophyll seems to be particularly indicated: first, in the treatment of open wounds; and second in the treatment of deep infections associated with drainage tracts communicating within the body cavities such as the abdomen or chest. For open wounds, dressings saturated with chlorophyll solution may be applied as often as may be necessary, without fear of skin irritation. Tidal irrigations, by means of inlaying tubes within the dressings, may be required in cases of extensive suppuration. Its use on freshly denuded surfaces is desirable to promote healthy granulation and wound healing. In wounds with large skin defects, where skin grafting is contemplated, the solution is advantageous to limit suppuration and to hasten border skin regeneration.

"In the treatment of suppurative processes within the abdomen or chest, the drainage tract should be irrigated at regular intervals with the chlorophyll solution. Soft rubber tubing (Dakin tubes) may be introduced into the sinus, and the

solution allowed to flow in by gravity. If it is desirable to flood the wound several times daily, copious dressings should be applied around the tubing, so that irrigation may go on without exposing the wound with each treatment.

"In empyema it is suggested that the cavity be flooded at least three times within twenty-four hours, when drainage is profuse. Irrigations need not be interrupted if bronchial fistula exists. Experience has shown that the solution may enter the bronchus and be expectorated without discomfort. It is best, when dealing with bronchial fistula, to allow the solution to enter cautiously, to avoid flooding the respiratory tract, and have ready a suction apparatus to recover the solution, should respiratory embarrassment occur.

"Experience has also shown that suppuration within the abdominal cavity may be treated advantageously with chlorophyll solution. Recently, a large left subphrenic and perirenal abscess with drainage of abundant odorous pus, caused a patient much distress. With irrigation of the abscess cavity there was prompt disappearance of odor and marked reduction in the suppuration, within two days after the chlorophyll treatment." From Dr. Coombs' experience, he believes that "in chlorophyll we have available a safe and non-irritating agent which offers a distinct aid in the treatment of wound suppuration. It is interesting to note that after the administration of chlorophyll, the character of the discharge is changed, becoming thinner, and later almost watery in consistency, especially when granulation tissue is beginning to form."

In the application of chlorophyll in otolaryngology, Dr. Robert F. Ridpath and Dr. T. Carroll Davis report a series of 1000 cases treated at Temple University Hospital and Clinic, of which 80 per cent were acute rhinitis and rhinosinusitis, the other 20 per cent being largely chronic sinus conditions. They state: "The following method of treatment was adopted. In acute cases, the nasal chambers are

shrunk and anesthetized, after which a modified Dowling pack is used, that is, a thread is attached to each pack, which is saturated with chlorophyll solution and gently inserted into the nasal cavity, until the posterior end of the pack, passing between the middle turbinate and the septum, is resting in the region of the superior meatus, in close contact with the ostia or the sphenoid and posterior ethmoid sinuses. The anterior end is gently packed into the middle meatus, thereby coming in contact with the ostia of the sinuses emptying there, namely, the frontal, anterior ethmoid, and maxillary. The ends of the thread attached to each pack are tied together across the septum, and are cut off close to the knot, so that the patient may go about without being conspicuous and may remove the packs himself by pulling on the thread. It is advisable that the patient retain the packs for at least one hour. The patient should be given a daily treatment, and the treatment should be repeated in at least twenty-four hours in all cases."

They further state: "Chlorophyll is preferred because it is less irritating than the colloidal silver salts. The results obtained with the chlorophyll packs have been very pleasing in that the drainage from the sinuses seems to be tremendously increased, so that a number of our patients declared that one treatment had cleared up their cold. We do not mean to indicate that one treatment will cure all acute cases, but it has rarely been necessary to give more than three.

"In the treatment of chronic sinusitis, the procedure is to have the patient procure a suction apparatus. The most satisfactory has been an aspirator of the improved Chapman water pump type. The patient is directed to take the position recommended by Proetz,<sup>5</sup> or that recently recommended by Parkinson.<sup>6</sup> While lying in this position 2 to 3 c.c. of the chlorophyll solution are inserted into each nostril. The patient then uses the suction obtained with the pump described above. While applying



the suction, the patient must be careful to close all nasal outlets by the method developed by Dr. Proetz. This treatment is used once each day. Since results cannot be obtained so quickly as in the acute cases, the treatment should be continued until improvement is noted. As the patient is able to give himself the treatment or have it given in his home, he is more likely to persevere with it. We believe that failures occur simply because the patient cannot visit his physician for daily treatments over an extended period of time. By the method given here, the patient is simply required to visit his physician occasionally, so that a check-up may be made from time to time."

Dr. Ridpath reports that four patients with chronic maxillary sinusitis who had refused operation, and who had been treated previously by several other rhinologists and by himself without any perceptible improvement, were treated by the usual lavage of the sinuses. After all moisture was drained by posture and instillation of air, the cavity was filled with chlorophyll solution. This was permitted to remain. The treatment was given every other day. After four weeks, improvement was noticed both in the amount of the discharge and the condition of the patient. The treatment was continued for several months, with a final cure of all former symptoms.

In chronic otitis media, Dr. Ridpath reports, "These patients had been operated on previously for mastoiditis, but unfortunately in some cases of this type there is a continuation of the discharge. The method of treatment in these cases was, to cleanse the canal by the dry method and instill the chlorophyll solution until the canal was full. These instillations were continued by the patients several times a day, the patient returning to the office weekly. In all cases, sufficient improvement was noticed for me to consider chlorophyll a very valuable remedy."

In the preceding paragraphs relating to the treatment of surgical infections and otorhinolaryngologic pathology, the chloro-

phyll has been used in an aqueous solution, which is made up as follows: 2 Gm. of chlorophyll is dissolved in a liter of distilled water to which is subsequently added 8.5 Gm. of sodium chloride, C.P., to produce an isotonic solution. This material is then filtered three times through a fine grade of filter paper, put up in containers of convenient size and autoclaved. The final product represents 0.2 per cent solution of one of the water-soluble derivatives of chlorophyll. For surgical wounds, no appreciable difference is noted in the reaction to the different forms of chlorophyll, but in otorhinolaryngology, it appears that the magnesium salt is less irritating to the mucous membranes.

We are also indebted to Dr. Carroll S. Wright, Professor of Dermatology and Syphilology at Temple University School of Medicine. He has utilized chlorophyll in ointment form in the treatment of various skin conditions and has found it particularly helpful in chronic ulcers, especially those of the indolent, varicose type. Very good results have also been obtained in the treatment of impetigo contagiosa. Dr. Wright has been so favorably impressed that he is continuing its use, and we hope to be able to quote more extensively regarding the place of chlorophyll in the field of dermatology in the near future.

In such skin lesions, the chlorophyll is used in the form of an ointment made with lanolin as the base. The oil-soluble chlorophylls, A and B, are used in the preparation of this ointment in a strength of 1 Gm. of chlorophyll to 28 Gm. of lanolin. The chlorophyll is ground to a fine powder and added to the softened lanolin and mixed thoroughly, after which the ointment is autoclaved and poured into sterilized jars. After autoclaving, a layer of water containing a high percentage of chlorophyll will settle to the bottom of the container. This should be thoroughly mixed into the ointment while still warm, using a sterile rod or spatula.

Still further use of chlorophyll has been found in the fields of proctology and



gynecology. The oil-soluble forms of chlorophyll have been utilized as suppositories. These are prepared like the ointment, by mixing finely ground chlorophyll with monolene (propylene glycol stearate), in the same strength of 1 Gm. of chlorophyll to 28 Gm. of monolene. In this instance, 10 c.c. of distilled water are added. When the chlorophyll is evenly distributed throughout the base, the resultant mixture is moulded in a suppository press and is ready for use. The use of these suppositories in chronic lesions of the rectum and in cases of cervicitis associated with marked leucorrhea has been most promising. The discharge from several leucorrhea has been cleared up in almost every instance, with comparatively few applications of the chlorophyll. At present, it is being investigated in respect to *Trichomonas* infections of the vagina, but the data are not yet available for analysis.

It is obviously impossible to include in detail individual protocols of cases treated with chlorophyll. These records, however, are all available for reference. Over 1000 cases have been treated by Drs. Ridpath and Davis in their otorhinolaryngologic work. These have ranged from mild acute coryza or rhinitis through associated acute sinus infections, to chronic rhinosinusitis. They include severe cases of suppurative pansinusitis, ethmoiditis, sphenoiditis, acute infections of the maxillary antra, of the frontal sinuses, and changes associated with turbinate deformities. The patients ranged from young children to elderly individuals. The length of treatment has varied from a single instillation of the drug to prolonged treatment of as long as a month, the number of treatments during such periods averaging three to four, but in some few instances having been carried on in the more chronic conditions to as many as nine or ten. Perhaps deserving special comment are two cases of atrophic rhinitis associated with chronic sinusitis. These have been under treatment for several months with marked improvement while under therapy, but reverting when

this was omitted. In the entire series as reported by Drs. Ridpath and Davis, it is interesting to note that there is not a single case recorded in which either improvement or cure has not taken place. One must, of course, recognize the part which psychic therapy plays in many patients whose disease is relatively trivial in character, but nevertheless it is striking that not a single failure seems to have occurred in this rather extensive series of cases.

In the surgical field, again, a wide variety of conditions have been treated, including such diverse lesions as typhoid osteomyelitis, chronic varicose ulcers, postoperative infections following cholecystectomy and appendectomy, empyema, actinomycosis of the thoracic wall and pleura, gangrenous appendicitis, infected herniation of the brain associated with a brain abscess, peritonitis, perinephritic abscess, ruptured lung abscess with associated empyema, suppurative arthritis, compound comminuted fracture of the femur with suppuration, Vincent's angina, carcinoma of the uterus, and pyorrhea. From this partial list of cases, it becomes apparent that the use of chlorophyll in any acute or chronic suppurative process has resulted in definite improvement. Even in the case of actinomycosis cited above, which occurred in a 15 year old child, the discharge from the sinus tract diminished in amount and the sinus became lined by what appeared to be healthy granulation tissue. Unfortunately, due to a change in service at that time, the chlorophyll was discontinued and replaced by x-ray therapy. It was interesting to note, however, that while under chlorophyll treatment, the patient's condition seemed to improve and the local lesion showed definite reparative features.

In connection with infections of the mouth, it has been interesting to note, particularly through the kindness of Dr. Homer Junkin of the Paris Hospital in Illinois, that Vincent's angina and advanced pyorrhea can be very successfully controlled by intensive use of chlorophyll. In this latter condition, it is actually

injected into the gums and between the teeth as well as applied superficially. Within less than a month, the gums tighten up about the teeth. All purulent discharge ceases, and the infection appears to clear up entirely.

Dr. Clifford J. Ulshafer, chief surgeon of the Locust Mountain State Hospital (Pennsylvania), has used a solution of chlorophyll in streptococcic septicemia as well as in subacute bacterial endocarditis. He has found that daily administration, for a period of six days, of the chlorophyll solution in a quantity as high as 250 c.c. intravenously, produced no toxic effect, and has reported a case of streptococcic septicemia in which an uneventful recovery followed the intravenous administration of chlorophyll solution. He also reports a case of subacute bacterial endocarditis which is interesting in that, while the patient was given chlorophyll, the blood cultures were absolutely negative, but blood cultures taken three or four days after the use of chlorophyll was discontinued were again positive. The blood stream could not be kept negative for streptococci without the use of chlorophyll daily, evidently the result of continuous septic emboli being discharged into the circulation. The patient was given 250 c.c. of chlorophyll intravenously daily, for six consecutive days, with negative blood cultures during this time, and for two days following the last injection. Apparently no ill effects were suffered from the chlorophyll, as repeated blood urea, creatinine, and urine analyses were done, and there was no evidence of hepatic damage.

#### SUMMARY

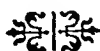
The use of chlorophyll in the treatment of acute and chronic suppurative conditions is suggested. A theoretical consideration of its mechanism is presented. Its

chemistry is reviewed briefly. Its use in surgical conditions, in otorhinolaryngology, in dermatology, and in a variety of other fields is reviewed, with a summary of the results obtained in some 1200 cases.

I wish at this time to acknowledge the support of the physicians who have utilized the chlorophyll preparations, especially Dr. W. Wayne Babcock, Professor and Head of the Department of Surgery, Temple University School of Medicine; Dr. J. N. Coombs, Associate Professor of Surgery; Dr. W. Emory Burnett, Associate Professor of Surgery; Dr. Temple Fay, Head of the Department of Neurosurgery; Dr. Robert F. Ridpath, Professor of Laryngology and Rhinology; Dr. T. Carroll Davis, Assistant Professor of Laryngology and Chief of the Nose and Throat Clinic; Dr. A. Neil Lemon, Associate in Laryngology and Rhinology; Dr. G. M. Astley, Associate Professor of Surgery; Dr. H. A. Duncan, Associate Professor of Gynecology; Dr. W. A. Steel, Professor of Surgery; Dr. J. R. Moore, Professor of Orthopedic Surgery; Dr. H. Z. Hibshman, Professor of Proctology; Dr. W. H. Thomas, Professor of Urology; Dr. C. S. Wright, Professor of Dermatology; Dr. John H. Frick; Dr. H. S. Raines; Dr. Clifford J. Ulshafer, Chief Surgeon of Locust Mountain State Hospital (Pennsylvania); and Dr. Homer D. Junkin, Surgeon-in-Chief of Paris (Illinois) Hospital.

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# THE EFFECTS OF SUTURES ON THE STRENGTH OF HEALING WOUNDS\*

WITH NOTES ON THE CLINICAL USE OF ANNEALED STAINLESS STEEL WIRE SUTURES

DANIEL J. PRESTON, M.D.

PHILADELPHIA, PENNSYLVANIA

INCREASING attention has been given in recent years to the subject of tissue reactions and wound healing with relation to suture materials. Though the use of absorbable suture material prevails in many localities, there seems to be a trend toward the wider use of non-absorbable sutures. Experience is teaching that there are limitations which govern the results obtained with each suture material. The object of these experiments was to test the strength of healing wounds by mechanical methods to determine the effect of sutures on wound integrity.

This study was prompted by observations of reopened abdominal wounds at the operating table where one could see the gross changes produced in living tissues by foreign substances used to approximate wound edges. At the end of two weeks, an upper abdominal incision closed with strong catgut could be pulled apart easily with small retractors to expose grayish, rough, friable, poorly vascularized wound edges which appeared to be necrotic in places. This appearance was noted by Jenkins<sup>9</sup> in his study of disrupted abdominal wounds. He remarks on the difficulty of identifying the fascial landmarks in these wounds.

An upper abdominal incision closed with annealed stainless steel wire when reopened showed firm union of the wound edges which strongly resisted the pull with retractors. The beginning production of white fibrous tissue was evident at the end of two weeks in this wound and a scalpel was required to divide the layers.

The friable unhealthy appearance seen in wounds closed with catgut was not present.

The strength of wounds closed with catgut seemed largely dependent upon the partly digested sutures which remained. In the wounds closed with wire the healing apparently had advanced farther in the same period of time so that wound strength was due more to union of the layers and was less dependent upon the holding properties of the inactive wire sutures.

Numerous factors other than suture materials have their effects upon the rate of wound healing and the strength of the wound during the healing process. Reid<sup>10</sup> points out the importance of rest for wounds and the significance of an adequate blood supply to nourish the part and remove wastes. Howes and Harvey<sup>8</sup> have shown the effect of blood clot, infection, and chemical and mechanical trauma in delaying the onset of the fibroplastic process which initiates wound healing. Ebeling<sup>4</sup> has shown how an elevation of temperature increases the rate of cicatrization and he compares the effect of temperature on metabolism with the effect of temperature on a chemical reaction. Hertzler<sup>6</sup> remarks upon the interposition of fat, the action of aseptic necrotic tissue, the presence of digestive ferment, and the altered coagulability of the blood due to systemic disease as factors which prevent primary healing. Smelo<sup>11</sup> considers that the chief local factors detrimental to healing are foreign bodies, degree and type of infection, inadequate blood and nerve supply, and traumatism from the dressing.

\* From the Surgical Clinic of W. Wayne Babcock, Temple University Hospital, and the Laboratory for Surgical Research of Temple University Medical School, Philadelphia.

The remote detrimental forces he ascribes to improper diet, disturbance of endocrine glands, infection elsewhere in the body, and advanced age.

#### PROCEDURE

The animals selected for experimentation were two dozen adult male white rats which were maintaining their weight or had gained weight over a period of two weeks or more preceding operation. To a diet of "rat chow," a commercial preparation containing balanced food factors, were added leafy vegetables and an unlimited water supply. This diet was started two weeks or more before operation and was continued immediately after operation for all animals. They were kept in a common cage before operation. Rats which had been operated upon were kept together in another cage.

Ether anesthesia was used for all operations. The back was prepared by removing the hair from neck to tail with a pair of hand clippers. No water, soap, antiseptics, or germicides were used. A vertical incision measuring 9 to 10 cm. was made with sharp scissors down each side of the back, cutting through the full thickness of the skin. The incisions were then closed with sutures carried on a straight spear point needle. Four kinds of suture material were used, namely: No. 0 plain catgut, No. 0 chromic catgut, No. 1 braided "serum proof" black silk, and 35 B and S gauge annealed stainless steel wire. Only one kind of suture material was used on any one animal. The sutures were spaced so as to average three sutures per centimeter. For each kind of suture material, eight types of suturing were employed, namely: interrupted tight big bite, interrupted loose big bite, interrupted tight small bite, interrupted loose small bite, continuous tight big bite, continuous loose big bite, continuous tight small bite, continuous loose small bite. No dressing or protective device was used on any of the incisions. An effort was made to reduce chemical and mechanical trauma to a minimum during operation.

Two weeks after operation the animals were again anesthetized with ether. The wounds were inspected and all sutures

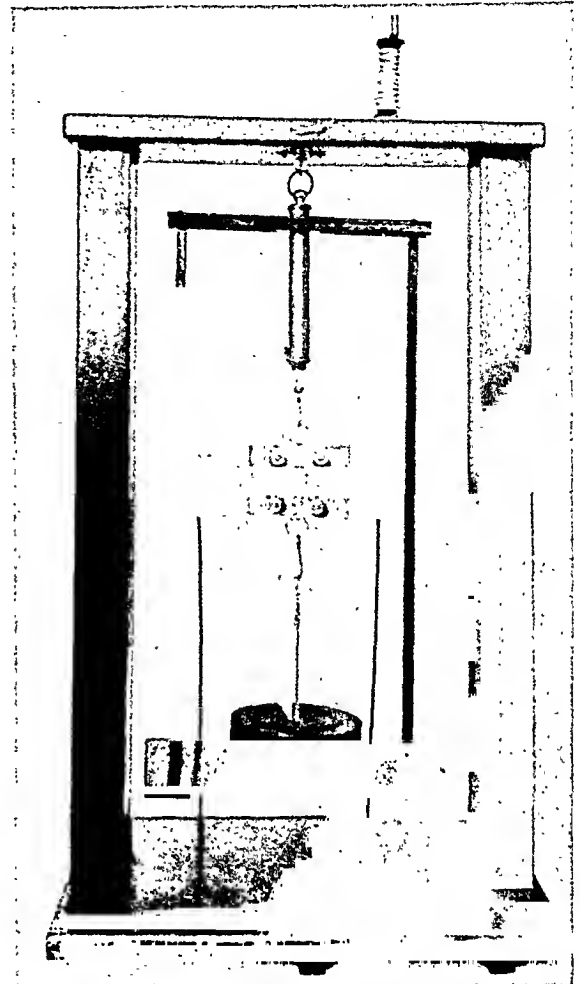


FIG. 1. Apparatus for testing the tensile strength of excised wound segments.

which remained were carefully cut and removed without disturbing the integrity of the wounds. This was done so that the strength of the wounds when tested would in no way be dependent upon the holding strength of remaining sutures. The skin wounds were then excised and segments were cut to measure 1 cm. These were tested without delay on the apparatus. The force necessary to pull apart a 1 cm. segment of incision was indicated on the scale. For each type of suturing used, two or more tests were made and the average recorded.

The testing apparatus (Fig. 1) consisted of a frame with parallel vertical supports holding a transverse piece at the top from

which was suspended a calibrated suture testing scale made by the Holland Company of Willimantic, Connecticut. Within

tion. Sixty per cent of these animals lost an average of 29.3 Gm., 40 per cent gained an average of 3.1 Gm., and none died dur-

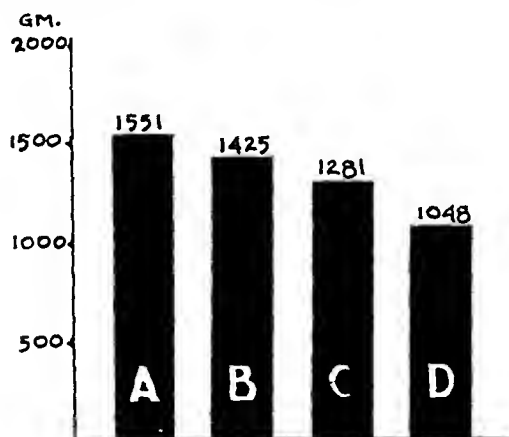


CHART I. Strength in kg. of 1 cm. excised skin wounds of rats at two weeks. The averages of test results on specimens closed by interrupted, continuous, tight, loose, big bite, and small bite suturing with: A, 35 gauge annealed stainless steel wire; B, No. 1 braided "serum-proof" black silk; C, No. 0 chromic catgut; D, No. 0 plain catgut.

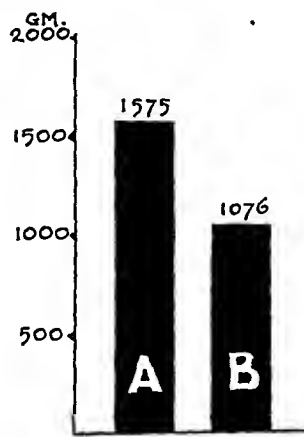


CHART II. Average tensile strength in kg. of 1 cm. excised skin wound segments of rats at two weeks. A, closed with interrupted sutures. B, closed with continuous sutures. Wire, silk, chromic and plain catgut were used with big bite, small bite, tight, and loose stitches for each suture material.

the vertical support was placed a rectangular platform bearing a 10 Kg. weight. From the testing scale hung a system of two clamps which held the ends of the excised wound segment to be tested. The platform bearing the 10 Kg. weight could be hoisted and the lower tissue clamp attached to it. By lowering the platform slowly the tissue clamp system could be made taut and at this point the platform was halted and made fast by a supporting twine tied above. When the twine was cut with scissors, the falling 10 Kg. weight on the platform pulled directly against the vertically arranged tissue clamps and testing scale system with more than sufficient force to pull apart the segment of incision held between the clamps. The amount of force which the incision resisted before breaking was registered on the testing scale. An accurate reading of the strength was facilitated by a ratchet which prevented the scale from snapping back when the tissue broke and the pull ceased.

#### RESULTS

The average weight of the rats used was 198.6 Gm. at the time of the first opera-

ing the two weeks interval between operations.

Table I, column A, tabulates the results of tests on wounds which had been closed with No. 0 plain catgut. The interrupted loose big bite specimen showed several enlarged stitch holes with a small zone of necrosis and scanty purulent discharge. This portion was not included in the tests since it appeared much weaker than the remainder of the wound. All of the wounds appeared slightly swollen and most of the stitch holes showed a local zone of erythema. The weakness of the interrupted loose small bite specimen seemed to be due to an increased involvement of the wound edges by tissue reaction to the sutures.

Table 1, column B, lists the tensile strength of wound segments which had been closed with No. 0 chromic catgut. A similar local reaction around these sutures, as seen in the plain catgut incisions, was present but seemed less marked. The

interrupted tight big bite and continuous loose big bite specimens showed pus around several of the sutures. In the continuous tight small bite and interrupted loose small bite specimens the suture material had been completely extruded or absorbed, and these wounds did not show infection.

Table 1, column C gives the results of tests on wounds which had been closed with No. 1 braided "serum proof" black silk. Several wounds showed very little reaction to the suture. Others had a zone of erythema around the stitch holes but only the continuous loose big bite specimen showed pus in the stitch holes.

Table 1, column D, lists the tensile strength of wounded segments which had been closed with 35 gauge annealed stainless steel wire. There was a minimum of reaction about the sutures. No swelling, no zone of erythema, and no gross infection were seen in any of these wounds. The sutures had been extruded from the interrupted tight small bite specimen. The edges of skin in the continuous tight big bite specimen had been rolled in, due to the type of suturing, which gave no edge-to-edge contact. This resulted in an unsatisfactory and weak wound.

TABLE 1\*

Type of Suturing	A	B	C	D
Interrupted tight big bite.....	1010	620	1360	820
Interrupted loose big bite.....	2520	930	1880	1970
Interrupted tight small bite.....	590	930	1880	1970
Interrupted loose small bite.....	500	2540	2260	2220
Continuous tight big bite.....	540	1760	820	690
Continuous loose big bite.....	890	820	1020	1280
Continuous tight small bite.....	840	770	710	570
Continuous loose small bite.....	1300	820	1260	2540

\* Tensile strength in Gm. of 1 cm. excised skin wound of rat at two weeks. Column A, wounds closed with No. 0 plain catgut. Column B, wounds closed with No. 0 chromic catgut. Column C, wounds closed with No. 1 braided "serum-proof" black silk. Column D, wounds closed with 35 gauge annealed stainless steel wire.

Chart 1 compares graphically the averages of results listed in Table 1. It shows the superior tensile strength found in wounds

closed with non-absorbable sutures. The absence of tissue reaction and gross infection about the wire sutures may have been

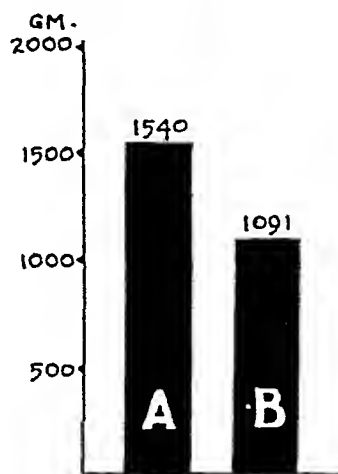


CHART III. Average tensile strength in kg. of 1 cm. excised skin wound segments of rats at two weeks. A, sutures loose, sufficient for approximation of wound edges. B, sutures tight. Wire, silk, chromic and plain catgut each used with interrupted, continuous, big bite, and small bite types of suturing.

the factors accounting for the greatest average strength of the wounds closed with wire.

Charts II, III, and IV compare the tensile strength of wounds with regard to the types of suturing used without consideration of the kind of suture material used. Chart V is derived from Charts II, III, and IV. It is a graphic comparison of the type of suturing which gave the strongest wounds and the type which gave the weakest wounds. This shows the detrimental effect on wound strength of continuous tight big bite sutures which reduce blood supply to the wound, and the favorable effect of encouraging blood supply by the use of interrupted loose small bite stitches.

#### COMMENT

According to Howes,<sup>7</sup> an ideal suture should fulfill the following postulates:

1. It should hold the wound edges together until the wound is healed.

2. It should not be affected by or take part in any untoward reaction during healing.

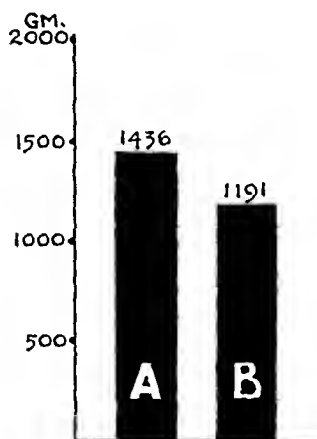


CHART IV. Average tensile strength in kg. of 1 cm. excised skin wound segments of rats at two weeks. A, small bite suturing. B, big bite suturing. Wire, silk, chromic and plain catgut each used with interrupted, continuous, tight and loose types of suturing.

3. It should be absorbed or become innocuous shortly after the wound is healed.

Annealed stainless steel wire was first introduced as a surgical suture and ligature in 1932 by Babcock.<sup>1,2,3</sup> It was the only suture material used in these experiments which fulfilled the requisites for an ideal suture.

The ability of a contaminated wound to heal without suppuration when closed with stainless steel wire is illustrated by the following representative case.

**CASE 1.** E. K., a school girl aged 15, entered Temple University Hospital on December 9, 1937, with a chronic abdominal sinus, discharging pus. An appendectomy for acute perforated appendicitis had been done elsewhere in February, 1937. The wound had healed after six weeks. In May, 1937 a large pelvic abscess had been drained through the abdomen and the chronic discharging sinus had persisted since then. Roentgenograms taken after iodized oil had been injected into the sinus showed two large globular shadows at the pelvic inlet on the left side. At operation a gauze sponge left

in the abdomen at previous operation was removed from the pelvic abscess. Iodoform gauze was packed into the abscess cavity and

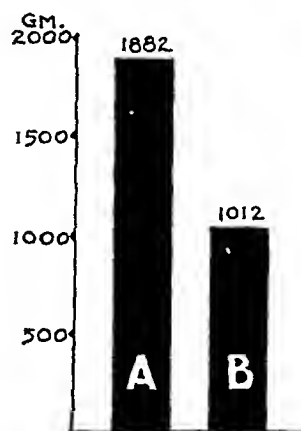


CHART V. Average tensile strength in kg. of 1 cm. excised skin wound segments of rats at two weeks. A, interrupted loose small bite suturing resulted in the strongest wounds. B, continuous tight big bite suturing resulted in the weakest wounds. 35 gauge annealed stainless steel wire, No. 1 braided "serum proof" black silk, No. 0 chromic catgut, and No. 0 plain catgut were used for each.

later brought out through an incision in the posterior vaginal cul-de-sac. The abdominal wound which had been grossly contaminated by pus was closed in layers with annealed stainless steel wire without a drain. An anaerobic culture of pus from the pelvic abscess grew many hemolytic streptococci. The patient was allowed out of bed on the fifth postoperative day. Skin sutures were removed from the abdominal wound on the seventh postoperative day. No suppuration occurred in the abdominal wound which healed per primam, and the patient left the hospital on the ninth postoperative day.

Wire sutures buried in a contaminated field do not act as a nidus for infection as may occur when catgut or silk are employed. In a grossly infected wound wire sutures heal in and are covered by granulation tissue without the formation of infected sinuses. Wounds of the mucous



membranes heal favorably when closed with stainless steel wire as reported by Jenkins.<sup>5</sup>

In a clinical study of thirty-six cases of abdominal wound disruption Jenkins<sup>9</sup> found that thirty-one of these had been closed with chromic catgut, four with linen, and one with silk. During absorption of the catgut the local reaction to foreign protein substances delays healing and produces edematous friable wound surfaces, which causes dangerous weakness in abdominal wounds under tension. The following case report emphasizes the undesirable qualities of catgut where early strength of the wound is required.

CASE II. Mr. W. G., aged 66, entered Temple University Hospital on November 18, 1935, for radical resection of a carcinoma of the rectum. A one stage abdominoperineal proctosigmoidectomy with formation of a perineal colostomy was done on November 21, 1935. The vertical lower left rectus abdominal wound was closed with continuous No. 1 chromic catgut for the peritoneum, continuous No. 2 chromic catgut "reinforced" with interrupted stainless steel wire sutures for the anterior sheath of the rectus, and the skin was closed with continuous wire sutures.

His condition was satisfactory after operation. The skin sutures were removed on the sixth postoperative day. Several hours later a loop of small intestine was found to have protruded between the wound edges and was lying between the gauze dressing and the skin. The wound did not show evidence of gross infection and was immediately resutured. Suppuration of the wound followed and the patient's condition was critical for several days. When he left the hospital one month after admission, the abdominal wound was healed but showed a large reducible incisional hernia.

In this case both wire and catgut were used to close the rectus sheath which is important in maintaining the strength of this type of wound. The use of wire to "reinforce" the continuous catgut suture gave the operator a false sense of security since the reaction of the tissues to the catgut with delay in healing occurred just as if the wire sutures had not been used.

In two years of observation I have not seen an abdominal wound disruption where wire alone was used to close the abdominal wall.

The possibility of receiving puncture wounds of the hands and fingers from the ends of wire sutures is a constant danger. The perforation of the glove which breaks sterile technique is a hazard to the patient. Perhaps a greater danger is borne by the operator, especially when working in a septic field. This is illustrated by the following case report:

CASE III. Dr. G. A., a surgeon, aged 56, was admitted to Temple University Hospital on January 20, 1938, with a cellulitis of the left index finger, lymphangitis of left arm and forearm, and enlarged tender lymph nodes in the left axilla. On January 18, 1938 while amputating a leg for diabetic gangrene with hemolytic streptococcic cellulitis he accidentally punctured his left index finger with the end of a wire suture. The finger was washed at once with a solution of mercuric chloride. Thirteen hours later the finger became red, swollen, and had a throbbing sensation. Within twenty-four hours after the injury he had a chill and the temperature rose to 103°F., at which time red streaks were visible on the flexor surface of the forearm and arm. A culture from pus released by incision of the left index finger on January 26, 1938 grew hemolytic streptococci in pure culture.

To guard against punctured wounds from wire ends, a hemostat clamped over the end of the wire by the nurse before handing it to the operator is a worthwhile precaution.

Since there is a minimum of tissue reaction around buried wire sutures there is less tendency for local fibrosis and encapsulation of the suture when healing is completed.

CASE IV. Mrs. D., housewife of 46 years, who had had a cholecystectomy twenty-three months previously, returned to the out-patient clinic with a 2 cm. piece of stainless steel wire which she had pulled out of the skin overlying the right tibia. A slight sticking sensation on pressure over this point had been felt for about



two months before the end of the wire perforated the skin and was pulled out. There was no inflammatory reaction or discharge from the small puncture wound over the right tibia and it healed without treatment.

In this instance the short straight piece of wire had probably been left in the cholecystectomy wound by accident during operation. Apparently it was propelled along fascial planes by muscular action much the same as a small straight needle would be. The precaution of clamping both ends of a wire suture with a hemostat after the knot is tied and before the ends are cut will facilitate removing loose pieces of wire from the operating field.

The operator usually will find that he cannot work so rapidly with wire sutures at first as he can with the suture material to which he is accustomed. This is due to the different handling qualities of wire which may be compared to the difference in handling catgut and silk. In tying knots with wire more force is required, especially with the larger sizes. For this reason it has been found convenient to use a curved hemostat in grasping the end of the wire so that a good purchase can be obtained to lay each knot down firmly. As the wire is pulled in tying a knot, a point is reached where increased friction is felt and often the wire can be heard to creak. If a wire which has been stretched is examined under a microscope, one will find numerous fine transverse crevasses which were produced as the wire elongated during the pull. These markings act as fine teeth to increase the friction as a knot is tied and may play an important rôle in preventing disruption of the knot.

Buried wire sutures show on a roentgenogram. One radiologist has likened their appearance to flying gnats, the short cut ends representing wings. Because of the small size of the knots it is doubtful if they ever obstruct the view of the radiologist.

In the results of the experiments on rats, it has been shown that the chief factors responsible for variations in the tensile strength of healing skin wounds were local

tissue reaction due to the kind of suture material used, and modification of blood supply to the healing wound by the type of suturing employed.

A good blood supply to a wound is an important local factor during the healing process. If one studies a chart of normal skin temperatures of the human body one observes an indirect ratio between the skin temperature of a given part and the length of time required for wounds to unite in this region. A close parallel of skin temperature and local blood supply will be apparent when the vascular anatomy of a given region is understood. For these reasons, wounds of the head and neck heal quickly; following thyroidectomy the skin sutures may be removed on the second and third postoperative days, while skin sutures in abdominal wounds should be left until the sixth or seventh days, and in wounds of the feet until the eighth day or longer.

If the normal anatomic distribution of blood to any injury is discounted, then the operating surgeon becomes the greatest single factor influencing the healing of surgical wounds. He is responsible for selecting the suture material, placing the sutures, and tying the knots and it is upon these things that the rate of healing and the strength of clean surgical wounds chiefly depend.

#### SUMMARY AND CONCLUSION

1. Skin incisions in white rats closed with various absorbable and non-absorbable suture materials were excised at the end of two weeks and segments of the wounds were tested on a special apparatus to determine their tensile strength.
2. Skin wounds of rats closed with annealed stainless steel wire possessed the greatest average strength and showed the least local reaction to the suture material.
3. Skin wounds of rats closed with No. 0 plain catgut were the weakest and showed the greatest local reaction to the sutures.
4. Gross infection was not found in any of the wounds closed with wire, but was

present in some of the wounds closed with silk, chromic catgut, and plain catgut.

5. The type of suturing which resulted in the strongest skin wounds in rats was the interrupted loose small bite stitch. The wounds which were found to be the weakest had been closed with the continuous tight big bite stitch.

6. Comment on some of the clinical advantages and disadvantages of annealed stainless steel wire as a surgical suture is given.

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# SUBDURAL HEMATOMA

W. D. ABBOTT, M.D.

Attending Neurosurgeon, Mercy, Iowa Lutheran  
and Iowa Methodist Hospitals

AND

D. H. KAUMP, M.D.

Attending Pathologist, Providence Hospital

DES MOINES, IOWA

DETROIT, MICHIGAN

THE purpose of this paper is to emphasize the frequency of dural hematoma as a sequel to cerebral trauma and to discuss some of the salient pathologic and clinical features. Recent publications by other authors<sup>6</sup> and ourselves<sup>1,3</sup> have reviewed the historical and etiologic phases of the subject so that a repetition is not deemed advisable. In the past few years, many papers on this subject have appeared in the literature. Those of Putnam and Cushing, as well as those of Leary, have been particularly descriptive. According to these authors, hematomas may be divided into two groups, spontaneous and traumatic. The so-called spontaneous or vascular type of hematoma is found particularly in chronic wasting diseases, such as paresis, as well as in chronic and acute alcoholism. The traumatic or reactive form is found chiefly following trauma, but it overlaps the first group somewhat as it may be found associated with certain of the conditions just mentioned.

Although by no means the first to describe subdural hematoma, Virchow in 1857 brought this particular entity to the attention of physicians. He proposed the theory that in certain cases where there was chronic inflammation of the dura, an exudation of fibrin took place. Into this thin film capillaries grew, which under the influence of continued inflammation and hyperemia, ruptured and produced small hematomata which in turn became organized. This theory has profoundly influenced subsequent workers although much other work has been done and numerous other theories have been advanced.

*Anatomy.* The dura is thick, dense, inelastic fibrous membrane which lines the interior of the skull where it forms an

internal periosteum. The dura has a rich blood supply and receives numerous arteries. In the anterior fossa there are branches from the anterior ethmoidal, posterior ethmoidal, internal carotid, and middle meningeal arteries. In the middle fossa, branches enter from the ascending pharyngeal, internal carotid, and lacrimal arteries and the posterior fossa receives branches from the occipital, vertebral, ascending pharyngeal and middle meningeal arteries. The veins, with the exception of the middle meningeal vein, anastomose with the diploic veins and empty into the sinuses. According to Kaump and Love, as well as Hannah, the dura consists microscopically of three layers. The outer layer which lines the skull is composed largely of dense fibrous connective tissue, and it is in this layer that the large vessels course. The inner layer consists of fibrous connective tissue but in a somewhat looser arrangement than the outer. This layer apparently has a scanty blood supply and it is lined by a thin flattened layer of fibroblastic cells. The middle layer, with which we are most concerned, is composed largely of loose fibrous connective tissue in which there are many small vessels and numerous endothelial lined spaces which may be empty or which may contain blood cells.

*Histopathology.* Kaump and Love have reported a series of thirty post-mortem specimens of so-called subdural hematoma. Thirteen of the hematomata were of the traumatic type and the remaining seventeen were considered to be of the spontaneous type. The hematomata described in this series of cases were all of a similar character. There was no change in the outer or periosteal layer of the dura mater except in the case of older lesions where

phagocytes laden with pigment were usually seen. This pigment was largely in the form of hemosiderin and was seen in

occasional small collections of lymphocytes were noted, but it must be remembered that this reaction might be readily due to



FIG. 1. Roentgenogram revealing multiple linear fracture in the left temporal and parietal bones.

sections stained for iron. There frequently was some hyalinization of the connective tissue. The middle layer in which the hematoma formed was filled with blood in various stages of degeneration, the more advanced degeneration appeared in older lesions. The inner lining of the hematoma was composed of new connective tissue cells. This organization was best seen at the angle where the separation in the dura had occurred. At this place bands of newly formed fibroblasts projected into the degenerating blood clot. In this new tissue and external to it were seen the dilated endothelial lined spaces which occasionally contained erythrocytes. These spaces were irregular and varied greatly in size. The inner or meningeal layer was thickened, edematous and contained many fibroblasts in the process of organizing the clot.

In a few of the cases sections were taken from positions remote to the site of the hemorrhage. These were examined for evidence of chronic inflammation particularly, and so far as could be determined they appeared to be normal. This does not, however, eliminate the possibility of a localized area of inflammation predisposing to hematoma formation. In examining the sections taken through the hematomata,

destruction of blood as to any chronic inflammation.

In the one case in which there was clinical and serological evidence of syphilis, and in which the lesions resembled miliary gummas, the lesions were undoubtedly due to syphilis and in this case may conceivably have played a part in the production of the hematoma. In all three cases in which there was an associated blood dyscrasia, collections of lymphocytes were noted. Here again as in the presence of syphilis, one must definitely consider the possibility of a local accumulation of lymphocytes playing a causative role in the formation of the hematoma.

Contradictory reports have been published as to the fate of blood subdurally injected, and Putnam and Putnam said in part that, "Apparently a true progressive chronic hematoma of the dura has never been produced experimentally. The lesions seen after the subdural injection of blood, and in patients after operation resembled a progressive lesion in appearance, but not in behavior." From a purely theoretical standpoint, it would seem plausible that blood set free in this potential space would flow to the dependent portions and fail to become encapsulated, simply because

of the diffuse distribution of the blood. In this regard, it might be said that in our experience at least, blood subdurally located

patients in the earlier stages, are not fully aware of the condition itself, its insidious developments and the methods whereby



FIG. 2. Encephalogram revealing slight dilatation of the ventricular system with no evidence of air over cerebral hemispheres.

at the site of trephine wounds organizes from the dural side only and shows no evidence of membranous formation. No evidence could be deduced from this series of cases which would put all cases of so-called subdural hematoma into one etiologic classification, that is, traumatic or spontaneous. It should be kept in mind that only relatively slight trauma may produce these hematomata and also that in the group of cases in which spontaneous hematomata appeared the history was often unreliable and mishaps of a slight nature could have readily been overlooked. These considerations together with the known etiologic rôle played by trauma in many cases tend to make one feel that they may well have all been of a traumatic nature.

**Diagnosis.** So-called subdural hematoma still goes unrecognized in a large percentage of cases. Neurologists and neurosurgeons who are constantly seeing cases of increased intracranial pressure and of cerebral compression usually consider the lesion in the differential diagnosis of many intracranial lesions, particularly if there has been a history of cranial trauma. The general surgeon and the general practitioner, however, who see most of these



FIG. 3. Posterior-anterior view of encephalogram, revealing absence of air over cerebral hemispheres.

diagnosis can be made during the optimal time for successful treatment.

The clinical picture presented by patients with subdural hematoma is quite confusing and any evidence of a pathologic nature which might aid in the identification of this condition is to be sought for. The latent period is perhaps the most characteristic of all the clinical features of so-called subdural hematoma and perhaps the most difficult to explain. The period preceding the onset of the neurologic signs may apparently be uneventful or in the cases in which there is a definite history of trauma, symptoms may be initiated by a period of unconsciousness immediately following the injury. The patient appears to recover from this in the space of a few minutes and then after a varying period of time, often several months, he begins to show definite neurologic signs.

It is possible that the cessation of bleeding is brought about by an increased intracranial pressure due partly to the hemorrhage. Into this clot grow newly formed vessels which are fragile and can

easily be damaged and lead to further bleeding. This theory of successive bleeding seems most logical, although Monroe and

the endothelial lined tissue spaces mentioned previously.

Perhaps the most confusing of the clini-

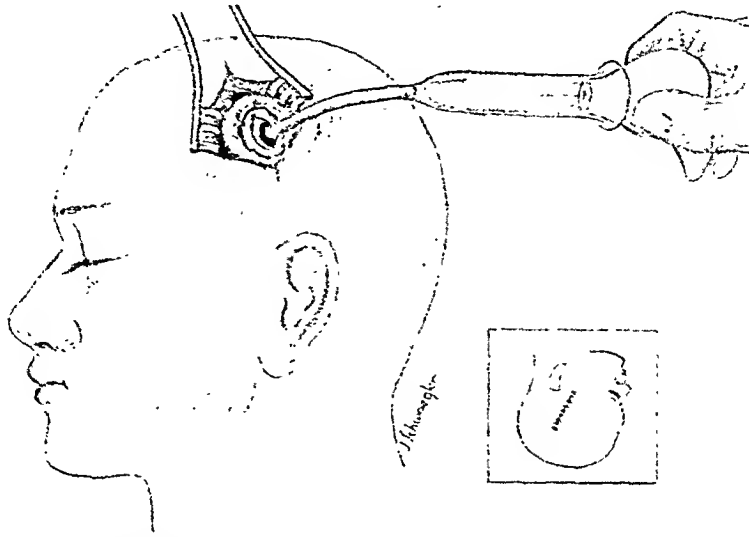


FIG. 4. Incision in superior temporal bone (small inset). Trephine opening and method of aspirating contents of hematoma (larger diagram).

Merritt have also postulated a very ingenious theory to explain the growth of these expanding lesions. They maintain that every subdural hematoma starts as a mixture of blood and cerebrospinal fluid. With the dissolution of the blood there is an increased protein content and with diffusion of fluid across the pia arachnoid there results an increasing volume of solution. This dissolution of blood with the consequent increased protein content covers a period of about sixteen days following which rapid dilution takes place for the two succeeding weeks. Slower dilution then takes place for at least two months. This explanation may be a logical one if we grant the admixture of blood and cerebrospinal fluid. This could occur only in case the arachnoid was torn and such an admixture obviously could not occur in hemorrhages which are truly intradural. Furthermore, the cerebrospinal fluid would, in cases of intradural hemorrhage, of necessity diffuse through the arachnoid as well as the inner layer of the dura. It might be just as logical to suppose that, if dilution actually does take place, the fluid added is derived directly from the blood stream by means of

cal signs presented lies in the bizarre nature of the neurologic signs. It must be remembered that a large unilateral tumor or hematoma may cause sufficient pressure to compress the opposite cerebral peduncle on to the cerebellar tentorium. This, of course, produces damage to the pyramidal tract and results clinically in paradoxical homolaterality of the pyramidal tract signs such as the Babinski reflex, spasticity, clonus and increased reflexes. The sensory relations remain undisturbed, as a rule, because of their deep seated location in the lemnisci.

The other group of clinical signs which might occur is general and is due to the increase in intracranial pressure. It is thus seen that this apparent confusion of clinical signs can best be interpreted in the knowledge of the pathologic change which may be present. Furthermore, in addition to the evidence gained by history and neurologic examination, diagnosis may be quite readily confirmed by the presence of choked discs and various changes in the reflexes, station and gait. In a few instances roentgenograms of the skull reveal calcification in a subdural hematoma, but these

usually are in patients in whom the lesions are more chronic in nature. More often it is necessary to utilize laboratory tests such as

dural hematoma are included in Tables I to V.

TABLE III  
SUMMARY OF SIGNS AND SYMPTOMS IN FIFTY-ONE PATIENTS WITH DURAL HEMATOMAS

	Number	Per Cent
Headaches.....	21	41.1
Personality changes.....	17	33.3
Vomiting.....	16	30.9
Convulsion.....	13	25.7
Paralysis.....	8	15.7
Coma.....	8	15.7
Unilateral dilatation of pupil.....	7	13.7
Choked discs.....	6	11.7
Latent period (5 days to 11 months —average 5½ months)		

TABLE IV  
Age: 10 months to 67 years  
Sex: Males 38—Females 13

TABLE V  
TECHNICAL MEASURES USED

	Number	Per Cent
Encephalography.....	10	19.2
Ventriculography.....	3	5.7
Trephine and drainage.....	35	67.3
Osteoplastic flap.....	16	30.7

#### CASE REPORTS

In order to demonstrate more graphically certain of the diagnostic difficulties which are encountered, we have summarized the salient features in six cases from this group of fifty-one.

**CASE I.** Female, aged 17, was in an auto accident September 5, 1933, which resulted in coma, paralysis of the right face, arm and leg, and laceration of the right arm. Gas gangrene developed September 17, 1933. Blood transfusion and gas bacillus serum were administered intravenously. On October 6 the patient was still in coma. The left frontoparietal flap was turned and the dural hematoma removed. The patient regained consciousness on October 13, moved her right leg October 14, and talked on November 10. Complete recovery ensued. This case illustrates the accompaniment of the rather rare complication of gas gangrene.

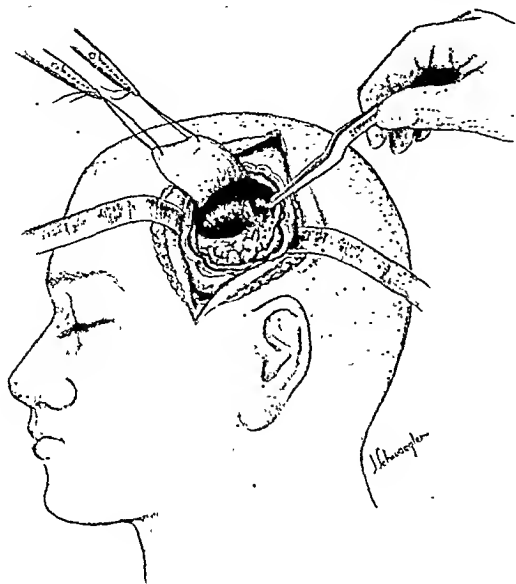


FIG. 5. Method of removing adherent hematoma from surface of brain.

cerebrospinal fluid studies to prove the existence of increased spinal fluid pressure and xanthochromic fluid. In many instances ventricular and encephalographic studies must be carried out.

TABLE I  
525 CONSECUTIVE HEAD INJURIES

Type of Injury	Number	Per Cent
Dural hematoma.....	51	9.7
Intradural.....	39	76.4
Subdural.....	12	23.6
Bilateral.....	23	45.1
Unilateral.....	28	54.9

TABLE II  
RESULTS IN FIFTY-ONE CASES OF DURAL HEMATOMA

	Number	Per Cent
Recovery.....	44	84.6
Death.....	7	15.4

**Clinical Material.** A summary of the findings and results in fifty-one cases of

Fortunately the patient survived both the hematoma and the gas gangrene.

CASE II. Male, 38, a known alcoholic, fell in a cement driveway January 21, 1934. He was thought to be drunk, and remained comatose. He was taken to the hospital seventy-two hours later. The right pupil was dilated and there was paralysis of the left extremities with a positive left Babinski. Roentgenograms revealed a linear fracture of the right temporal bone. (Fig. 1.) The spinal fluid was under increased pressure and xanthochromic. A dural hematoma was removed on February 1, 1934 and complete recovery followed. This case illustrates the role of alcohol. The confusion of an accident in a known alcoholic is obvious; a severe cranial injury may be present and be masked by symptoms of alcoholism.

CASE III. Male, 7, was struck by a car April 30, 1937. He remained semi-comatose for three days with headaches on exertion. Later there was a personality change, with failure in school and extreme irritability. Physical examination was essentially negative. Encephalography on May 26, 1937 revealed a bilateral defect over the cerebral hemispheres. (Figs. 2 and 3.) On June 10 the bilateral dural hematoma was removed and recovery followed. This illustrates the insidious progress of hematomata which are often first evidenced by headaches on exertion and marked change in personality.

CASE IV. Female, 39, was kicked in the face two days prior to admission and rendered unconscious. She was admitted in coma. There was a history of heavy drinking just prior to the injury. Examination was negative except for the obvious moribund condition. The patient expired thirty minutes after admission. Necropsy revealed a large dural hematoma compressing the right cerebral hemisphere. Here the rôle of alcohol had confused a possibility of the organic lesion which caused death.

CASE V. Male, 45, on August 15, 1935 suffered a severe head injury and was comatose for four days. Subsequently he developed gradual loss of memory and was placed in a psychopathic hospital for two months. Examination revealed an emotionally unstable male who cried readily and complained of vomiting. There was a right hemiparesis. On March 20, 1936, removal of bilateral dural hematomata resulted in complete recovery.

CASE VI. Female, 32, a known alcoholic, fell off a couch in an alcoholic stupor in February, 1938. She suffered from severe headaches and a right hemiplegia for three weeks. The spinal fluid revealed increased pressure and clear fluid. On examination she was dull and disoriented, with divergent strabismus of the right eye and a right hemiplegia. A dural hematoma was removed on the right. Exploration of the left cerebral hemisphere disclosed no abnormality. This illustrates a case of paradoxical homolaterality.

#### SURGICAL TECHNIQUE

In most instances these hematomas are of such chronicity that removal may be done through a small opening in the posterior temporal region. Evacuation is accomplished by irrigating the subdural or intradural space with saline solution followed by the application of a suction apparatus. (Fig. 4.) Occasionally the hematoma is so densely adherent to the pia that a larger opening must be made. This is done by turning an osteoplastic flap after which the clot can usually be satisfactorily evacuated. (Fig. 5.) It is our custom to make an incision and small trephine opening in the posterior temporal region on each side so that a bilateral dural hematoma will not be overlooked. The postoperative care differs somewhat from the routine care following removal of the usual cerebral tumor. Coleman has shown that following long compression, the brain does not return to its normal proportions and these patients frequently die from continued cerebral compression. Therefore, it is our custom to administer fluids generously to these patients for several days. If signs of cerebral edema develop they may be combated by the use of hypertonic fluids intravenously or by bowel and by judicious cerebrospinal fluid drainage.

#### SUMMARY

In this article are reviewed the salient clinical and pathologic aspects of dural hematoma. The intradural character of the clot, the pathologic picture and the paradoxical homolaterality of pyramidal signs



which may occur are stressed. Included is a review of the information gained from a study of fifty-one cases of dural hematoma as well as a summary of signs, symptoms and operative procedures used. Finally, we have included a summary of the findings on six patients in order to better demonstrate the diagnostic difficulties often encountered.

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A SATISFACTORY program for convalescing psychiatric patients includes an environment in which wholesome and attractive ways of living are maintained, an intelligent and well-trained nursing service, occupational therapy, physical education, and physiotherapy, all under medical supervision with opportunity for frequent interviews of patient by physician. From—"Convalescent Care" (New York Academy of Medicine).

# RETROPULSION OF THE LUMBAR INTERVERTEBRAL DISCS AS A CAUSE OF LOW BACK PAIN WITH UNILATERAL "SCIATIC" RADIATION\*

ROENTGENOLOGIC DIAGNOSIS, WITH SPECIAL REFERENCE TO IODOLOGY

J. MAURICE ROBINSON, M.D.

SAN FRANCISCO, CALIFORNIA

**S**EVENTY-FIVE patients have been operated upon at the Massachusetts General Hospital for the relief of symptoms resulting from compression of some portion of the spinal cord or cauda equina by a discrete, circumscribed cartilaginous mass protruding from the posterior margin of an intervertebral disc. Similar lesions have been recognized by neurosurgeons as a definite entity ever since Stookey's report in 1928 of eight cases of intervertebral disc "chondroma," all in the cervical region. It is now generally recognized that the terms "chondroma," "enchondroma," "ecchon-drosis," "fibroma," "fibrochondroma," etc., formerly used to describe them, were misnomers; these are not true tumors or fibrocartilaginous hyperplasia, but localized herniations or prolapses of the disc into the spinal canal. Prior to 1934 there were approximately forty-five of these cases in the entire literature. Elsberg's fifteen cases and the eight reported by Stookey accounted for about half of them. The others were covered in isolated reports from a dozen different sources.

The number has more than quadrupled in the past three years. This rapid increase has followed the discovery that unilateral lumbar ruptures† are the primary cause of disability in a certain percentage of patients suffering from recalcitrant low back pain with unilateral "sciatic" radiation down the posterior, lateral, or postero-

lateral surface of the thigh and calf. The clinical syndrome has been practically indistinguishable from that usually ascribed to recalcitrant low back strain, sacroiliac disease, idiopathic sciatica, etc., so that it has been necessary to consider these lesions in the differential diagnosis of these varied conditions.

Laminectomy and ablation of the offending nodule is attended by a favorable prognosis. Laminectomy is, however, a major surgical procedure, not to be lightly undertaken. Definite preoperative diagnosis is therefore of the greatest importance.

This paper will concern itself principally with the roentgenologic problems involved and more particularly with the examination of the subarachnoid space after iodized oil has been injected into it—a procedure which has come to be of paramount importance in determining both the presence and location of the rupture.

Various papers have already appeared describing the pathological, clinical, surgical and roentgenologic aspects of this interesting and important group of cases. In the first of these, which appeared in 1934, Barr and Mixter reported nineteen cases. They established that the histologic structure was that of some element of the intervertebral disc—nucleus pulposus, annulus fibrosus, or, more often, both. They also emphasized the presence in some of these cases of findings indistinguishable from lumbosacral or sacroiliac strain—painful rigid back, "sciatic" radiation of pain, limitation of straight leg raising, sciatic scoliosis, etc.

† The expressions "rupture" or "ruptured disc" used throughout this paper, refer to a rupture or prolapse of the disc *into the spinal canal*—a retropulsion—unless otherwise indicated.

\* From the Department of Roentgenology, Massachusetts General Hospital and the Division of Roentgenology, University of California Hospital. Presented in the Symposium on Fractures of the Spine before the American Academy of Orthopedic Surgeons, January 19, 1938.

Following this, similar cases were discovered with increasing frequency. In 1935 Mixter and Ayer added fifteen. Practically all of these were unilateral ruptures of the fourth or fifth (lumbosacral) disc. This was the first report in the literature of a group of cases in which the differential diagnosis lay, not between a true spinal tumor and rupture of the disc (or "chondroma"), but between rupture of the disc and some one of the orthopedic conditions mentioned. Concerning the differential diagnosis in many of these cases it is sufficient to quote from their paper:

"It is unnecessary to recount numerous friendly consultations with our orthopedic confrères over these debatable cases, but the essence of the consultation briefly would come to this, that all would agree that the clinical picture presented was characteristic of sacroiliac strain or other orthopedic condition, and that we should operate for a herniated disc only if shown by lipiodol."

In 1936 Hampton and the present writer reported the roentgenologic features of the first fifty cases operated upon. We discussed the refinements in technique by means of which it was possible to demonstrate a constant defect in the subarachnoid space in every one of the thirty-one cases operated upon after Mixter and Barr's initial report, although practically all of these were unilateral lumbar ruptures of the fourth and fifth (lumbosacral) disc, frequently producing but a slight extradural defect in the lateral portion of the sac, corresponding to no more than the width of the one or two roots involved.

In 1937 Barr published an exhaustive analysis of the entire group of lumbar ruptures. His article should be consulted for a detailed discussion and for a review of the literature. This was followed by papers by Mixter; and by Barr, Mixter, and Hampton, reporting further experience with this lumbar group, at that time numbering fifty-eight cases. In 1936 Love and Camp described six cases and in 1937

discussed a total of fifty cases\* in various parts of the spine. Forty-two of these were in the lumbar region. In the interval between presentation and publication of their paper forty-five additional cases were operated on and proved. In 1938 Naffziger, Inman and Saunders reported a group of cases from the University of California Hospital, approximately thirty of which were ruptured discs and the remainder, thickened ligamentum flavum. The anatomic studies carried out by Inman and Saunders confirmed many of the observations made by Hampton and the writer, and established a similar pathologic basis for the clinical significance of thickenings of the ligamentum flavum.

#### RELATION OF POSTERIOR RUPTURES (RETROPULSIONS) OF THE DISC TO SPINAL INJURIES

The question of the presence or absence of such a lesion may arise in the differential diagnosis of various injuries to the back. The actual relation between vertebral fractures and posterior ruptures of the disc appears to be remote, although it is possible that this opinion may be modified as further material accumulates. In none of the cases in this group was there an instance of definite fracture of any of the vertebrae, and in the series from the Mayo Clinic by Love and Camp there were only three instances. In none of these could a definite relationship be established between this finding and the presence of the posterior disc protrusion.

Kocker, in 1896, reported a case of complete rupture of the first lumbar disc occurring after a 100 foot fall of sufficient severity to cause the death of the patient soon afterward. At autopsy the adjacent vertebral bodies were found intact. In 1911 Middleton and Teacher reported the case of a man who developed paraplegia soon

\* At the time this article goes to press, more than 500 cases have been discussed. The number operated upon at the Massachusetts General Hospital and the University of California Hospital has been augmented at about half this rate and numerous reports from other institutions have appeared in the literature.

after lifting a heavy weight. The twelfth thoracic disc was entirely smashed, but the vertebrae were not crushed. They placed a section of spine in a vise so that the pressure was applied at the anterior edges of the disc. The inner fibers of the annulus fibrosus tore and gave way; the outer fibers were bulged outward by the expanding nucleus pulposus, but did not break. They noted that in this experiment, as in the autopsied case described by them, the protrusion took place to one side of the midline.

Dandy, in 1929, operated on two cases of loose intervertebral disc cartilage clinically simulating cauda equina tumor. He thought them most likely to be traumatic in origin. He considered them joint mice similar to those found in the knee and elbow, was able to obtain histories of preceding trauma, but suggested that repeated small injuries might be more important in their production. Inman and Saunders have analyzed the leverage involved when the lumbar spine is in flexion. Their results strongly support the belief that the original force applied to the flexed spine need not be great in order to exert a tremendous pressure on the disc.

Clinical evidence also tends to support the theory that trauma is the most important factor in the production of disc retropulsions. They occur about seven times more often in males than in females, and the patients usually are engaged in physical labor of some sort—mechanics, tailors, gardeners, nurses, etc. The average age in the group studied by Barr was 37 years, with 25 per cent under age 30. A history of trauma was obtainable in many instances—usually sudden pain in the back while lifting a weight; less often, twisting strains or a fall on the buttocks. In about half of these cases the pain persisted and radiated down the thigh and calf. In others, there were long intervals between the original injury and the present disability. A not infrequent history was disability for one or two months, remission for months to years, recurrence. Any one of the attacks,

all of them, or none might be associated with trauma.

The problem then is—just when did the rupture occur? Such questions cannot be answered at present with any degree of certainty. It is sufficient to point out that the literature on cauda equina tumors includes reports of lesions such as intradural neurofibroma, hemangioma, and other tumors treated for many years as sciatica, with remissions, and with few or no objective neurologic disturbances.

In a report from Schmorl's clinic in 1929, Andrae stated that he found single and multiple posterior protrusions of the discs in fifteen per cent of 338 spines examined by him post-mortem. These varied in size from a lentil to a pea, and were apparently too small to produce symptoms. He concluded that they were degenerative in origin. This group offers an interesting and rather marked contrast to the clinically important lumbar ruptures. Practically all the spines studied by Andrae were from individuals over the age of 60, mostly women. There were no retropulsions in individuals under the age of 30. *There were no retropulsions of the fourth or fifth lumbar disc.* It seems reasonable to suppose that if degeneration of the disc were the *primary* cause of the common lumbar retropulsions, a certain number should be found in a group such as Andrae's. Soon after Andrae's work appeared, Schmorl stated that he had seen one or two larger lesions in which the cord had been displaced, and stated that he believed others would be found. In his monograph (Schmorl and Junghans, 1932) he states that these lesions do reach a size sufficient both to compress the cord, and to produce complete block in the iodologram. He lists as probable examples the few "chondromas" which had found their way into the literature up to that time, and others classified as chordoma, myxosarcoma, etc. In speaking of a case reported by Zeno and Cames, classified as a fibrosarcoma, principally because of the sudden onset of pain and disability, Schmorl ex-

pressed the belief that it was really a posterior protrusion of the nucleus pulposus caused by sudden trauma.

#### RELATIONSHIP OF POSTERIOR PROTRUSIONS OF THE DISC TO OTHER FORMS OF DISC PATHOLOGY

Mixter and Barr, and Mixter and Ayer found that the majority of the lesions removed consisted of both the annulus fibrosus of the disc and the nucleus pulposus, rather than either element alone. It seems a misnomer, therefore, to refer to these lesions as posterior protrusions of the *nucleus pulposus*. The terms "rupture of the intervertebral disc into the spinal canal" or "retropulsion of the intervertebral disc," seem more accurately to describe their true nature. It appears to the writer for other reasons that it is a matter of some importance that the all-inclusive expression "rupture of the nucleus pulposus" should be avoided in describing them. Many writers have attempted to show relation between changes in the discs due to loss of nucleus pulposus substance and various forms of spinal disability. While the possible significance of such changes cannot be denied, there is no doubt that in some instances they have been over-emphasized. The spines of most individuals over 45 years of age show the more or less concave defects in the vertebral bodies with a zone of new bone reaction about them—the familiar radiologic picture of "Schmorl's nodule." It seems highly improbable that these are the cause of any significant disability. In other cases the loss of nucleus pulposus substance, either from trauma or degeneration of the disc, results in narrowing of the disc with or without localized hypertrophic arthritic changes. The settling of the bodies on each other following this is said to cause narrowing of the intervertebral foramina so that the nerve roots passing through them are compressed.

Perhaps this is true. It must be emphasized, however, that there is a distinct difference between such lesions and retro-

pulsions of the disc. In the former we are concerned with the changes which take place in the spine when the nucleus pulposus degenerates or ruptures, so that it no longer fulfills its usual functions—acting as a fulcrum for spinal motion, cushioning shocks, keeping the vertebrae apart, etc. A considerable literature which deals with this particular aspect of disc pathology has accumulated on the rôle played by destruction of the lumbosacral disc in the etiology of various forms of lumbosacral disability.

On the other hand, the retropulsions of the lumbosacral (or any other) disc are chiefly important, not because they represent a partial or complete destruction of the disc, but rather because of their purely accidental yet frequent behavior as a form of extradural spinal tumor. Failure to recognize this distinction has led to considerable misunderstanding concerning the clinical significance, diagnosis, and treatment of these lesions. As a result inadequate radiologic criteria, such as the presence of multiple nucleus pulposus defects in the vertebral bodies, narrowing of the disc, etc., are still being employed to diagnose posterior protrusions. It has been shown in every large series of "chondroma," and in similar series of posterior protrusions of the disc, that they are not constant findings.

Evidence of rupture of the nucleus pulposus into the vertebral bodies was actually noted in only a few instances, and in these cases appeared to be a purely incidental finding.

Ninety-five per cent of the lumbar ruptures studied by Hampton and the writer involved the fourth or fifth lumbar disc, the former twice as often as the latter. Narrowing of the fifth disc occurred as frequently when the rupture was at L<sub>4</sub> as when at L<sub>5</sub>, and this therefore proved of no localizing value, particularly as similar changes were found in patients in whom there was no reason to suspect a posterior rupture. The fourth lumbar disc was found to be narrowed in about a third of

the fourth lumbar ruptures, usually in conjunction with a narrowing of L<sub>5</sub> disc. It was never narrowed when the rupture was at L<sub>5</sub>. By disregarding the L<sub>5</sub> narrowings the narrowing of L<sub>4</sub> disc assumed suggestive localizing value, therefore, in about a third of the ruptures at that level. It is possible that this opinion must be modified, for Love and Camp, in an equally large series, found the L<sub>4</sub> disc frequently narrowed when the rupture was elsewhere, or when none at all was demonstrated.

As a matter of fact marked loss of lumbar lordosis, the result of muscle spasm, has proved to be a more accurate radiologic sign than any of the above if associated with "sciatica."

#### SELECTION OF CASES FOR IDOLOGY

Pressure of a tumor on the roots of the cauda equina often causes a local increase in the total protein content of the spinal fluid. Since the ruptures involve the lower lumbar discs, the spinal puncture needle often withdraws fluid from above instead of from below the rupture. The needle, if possible, should be introduced below the fifth lumbar vertebra, and the first sample of spinal fluid obtained should be analyzed. The total protein expressed in mg. per 100 c.c. (mg. per cent) decreases rapidly with increasing distance above the lesion. For this reason, and also because only one or two roots may be involved, the elevation is usually quite moderate in lumbar ruptures—usually 50 to 75 mg. per cent.

Originally lipiodol was never injected unless the spinal fluid protein was above 50 mg. per cent, but in recent years several cases have been discovered in which it was below this. These represent about 15 per cent of the total. Most neurosurgeons now feel that too much emphasis should not be placed on the absence of an increase in spinal fluid protein, but that the presence of an increase is valuable corroborative evidence. *At present lipiodol injection is considered indicated only in those patients with an elevated spinal fluid protein, those in whom an adequate trial of orthopedic treatment*

*had failed, those in whom some other definite explanation for the sciatica cannot be found, and those in whom a sacroiliac or lumbosacral fusion is contemplated.*

Twenty-one patients have not been operated upon because lipiodol failed to show a defect. Of these the protein was elevated in seventeen. The explanation for this is not known. Sicard, who apparently was the first to propose the theory that pressure on the roots in the intervertebral foramina from arthritis, etc., caused "sciatica," found an elevation of the globulin which he explained as due to pressure on the veins accompanying the nerve root in the foramen. This may or may not be an adequate explanation. Perhaps in some cases an error in lipiodol diagnosis was made. However, in six cases operated upon in which iodology was negative (in four of which the protein was elevated) nothing was found. The indications for operation in these cases were clinical, or operation represented an exploratory procedure preliminary to a contemplated fusion should nothing be found in the canal.

Certain neurologic findings were considered suggestive—particularly a missing ankle jerk on the affected side. This change was present in 50 per cent. Pain on coughing or straining, or on jugular compression, as well as objective sensory and motor disturbances of varying degrees were found in some of them. Similar changes have been described in other conditions: for example, Danforth and Wilson found the ankle jerk missing in 50 per cent of a group of "idiopathic sciaticas" studied by them, and such changes have been described in "sacroiliac strain." Some of these, of course, may have been retropulsions.

Sometimes, if the clinical syndrome was also suggestive, the presence of marked narrowing of the lower lumbar discs, indicative of degeneration or rupture of the nucleus pulposus, caused further investigation to be carried out to see if the rupture might not have taken place into the canal. However, lipiodol was not introduced unless the protein was first shown to be

elevated, or if, in the opinion of the neurologist, the other findings were of sufficient degree to justify it.

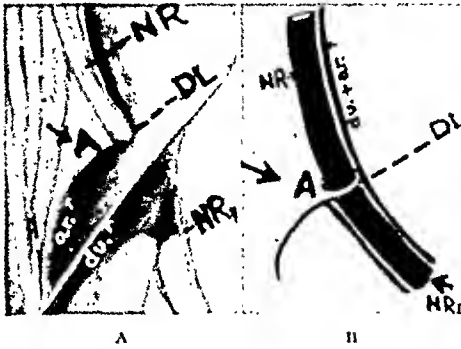


FIG. 1. Identification of anatomic structures in the iodogram. A, portion of the cauda equina. The dura, *du*, normally in contact with *ar*, the transparent arachnoid membrane, has been incised and laid back. A lumbar root is visible, leaving an outpocketing in the meninges. *DL*, the dividing line, drawn through the apex of the latter, separates the root into an "intradural" portion lying within the sac, and an "extradural" or sheathed portion outside of it. In the iodograms taken soon after injection, the periphery of the sac may be incompletely filled because more or less occupied by the nerve root. Only occasional streaks of lipiodol may be present between root and lateral sac wall. The latter, as well as the course of the extradural portion of the root, can, however, be reconstructed because they are in intimate contact with the inner border of the pedicle as far as the intervertebral foramen.

In those cases with obvious evidence of large cauda equina tumor, paralysis, sphincter disturbances, sensory changes, bilateral sciatica, block, definite protein elevation, etc., lipiodol was injected more to determine the type and site, rather than the presence of the lesion.

#### TECHNIQUE OF EXAMINATION

This technique, developed with particular reference to the demonstration of posterior protrusions of the disc, is based on the same principles as that described by Odin and Runstrom in 1928 for the demonstration of small spinal cord tumors. Camp, in this country, has developed and described a very similar procedure.

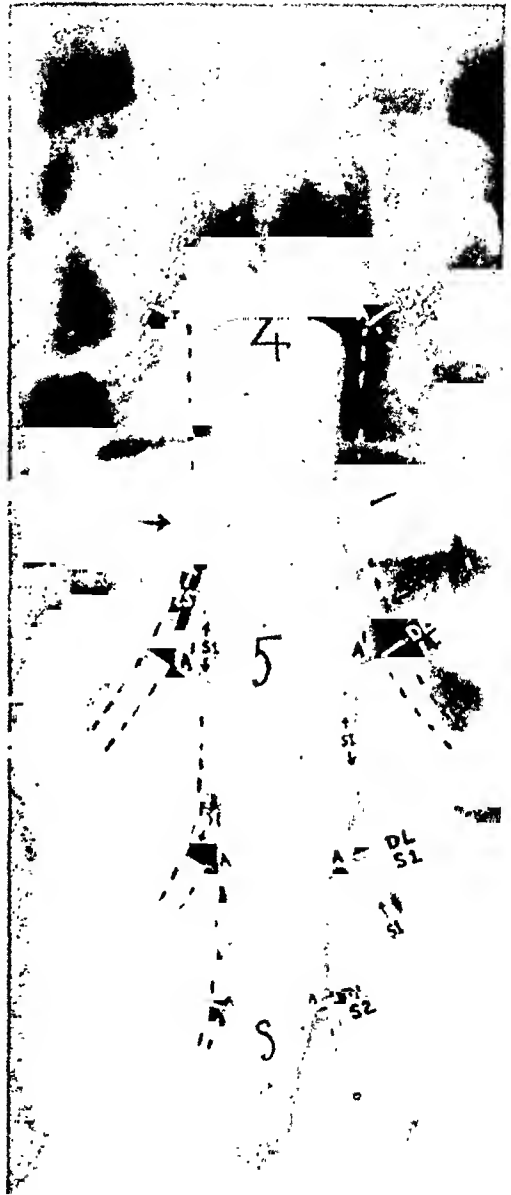


Fig. 1c. An operatively proved normal iodogram (5 c.c. of lipiodol in the lumbar subarachnoid space, patient upright) shows how an apparently asymmetrical sac assumes its correct anatomic appearance after the "pedicle lines" are drawn. Note that A, the portion of the outpocketing below the root, is readily identified on the films, so that *DL* can be established. Note also that fifth lumbar root, *L5*, leaves the spinal canal above the lumbosacral disc, hence retropulsions of the latter involve only the sacral roots. *L5* is most often involved by ruptures of the disc between the fourth and fifth lumbar vertebrae, which it crosses intradurally (note location of *DL*).

The use of adequate quantities of lipiodol—4 to 5 c.c. injected into the lumbar subarachnoid space is essential.

and not infrequently above the fourth lumbar. Since 95 per cent of the lumbar ruptures are at these levels, the optimal

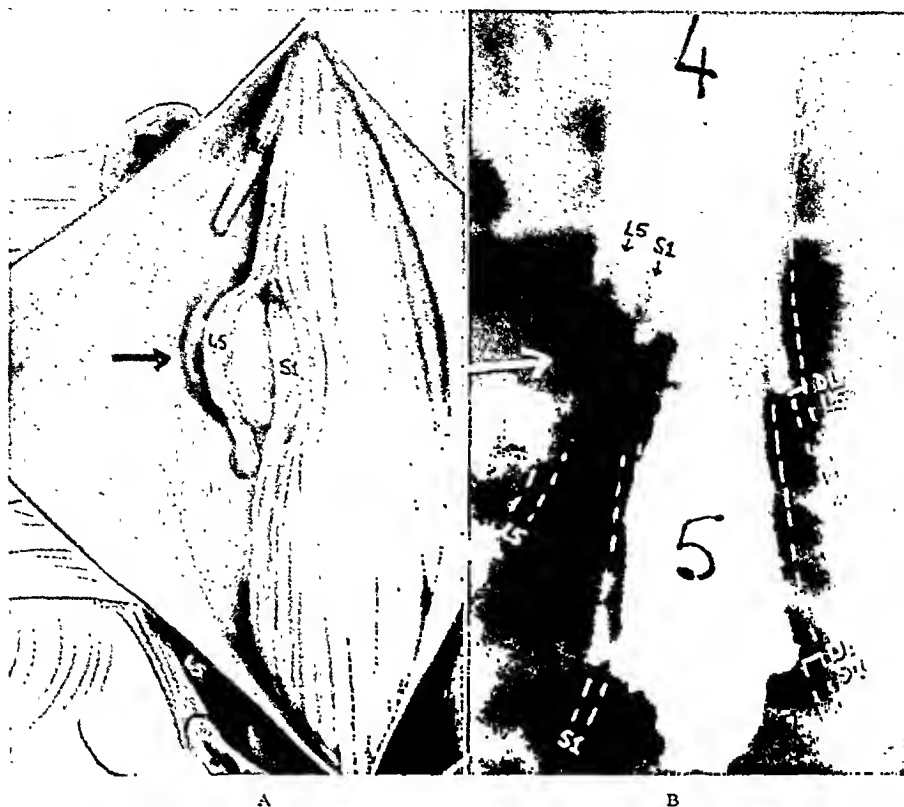


FIG. 2. The appearance of a left sided retro-pulsion of the fourth lumbar disc after the dura has been opened. The laminae and facets have been removed. The relation of the intradural roots to the ventral extradural mass elevating them should be noted. Compare this with B, which shows a corresponding lipiodol defect. Practically every structure in the one can be identified in the other. The dam-like action of the rupture has caused a more complete filling of periphery of the sac above the rupture than is present on the normal side at the same level. This phenomenon is almost invariably present (see Figs. 3, 5, 6, and 7) and hence is of diagnostic importance. It also makes the defect more obvious.

Examination is carried out principally in the prone and upright positions on a fluoroscopic tilting table which is equipped with a "change over" switch so that one may take instantaneous radiographs during fluoroscopic observation. The film is placed on the patient's back, the field limited to as small an area as possible by the shutters on the fluoroscopic screen in order to preserve detail, and exposure made with the tube below the table. Figures 1C, 2, 3, 4, 5, 6, and 7 show examples of these fluoroscopically aimed "spot" films.

With the patient upright, lipiodol collects in the lumbar sac. The upper lipiodol level will usually be above the fifth lumbar,

conditions for examination are present: the area in question is filled as completely as possible so that artifacts due to incomplete filling are avoided, leisurely examination can be carried out, and the position easily reproduced if it is desired to supplement the "spot films" with others. The discs at levels above those which can be examined in the upright positions are then studied by elevating the foot of the table, the patient lying abdomen down, and films are taken as the oil crosses the various discs. An attempt is made by manipulation of the patient to obliterate any defect seen, in order to prove that it is permanent. In this position gravity brings the lipiodol against



the anterior wall of the dura and into the narrow lateral portion of the lumbar sac, which is, for anatomic reasons, the area

face down on the table. The lipiodol column is studied fluoroscopically as it flows over the lumbar discs, and by various expedi-

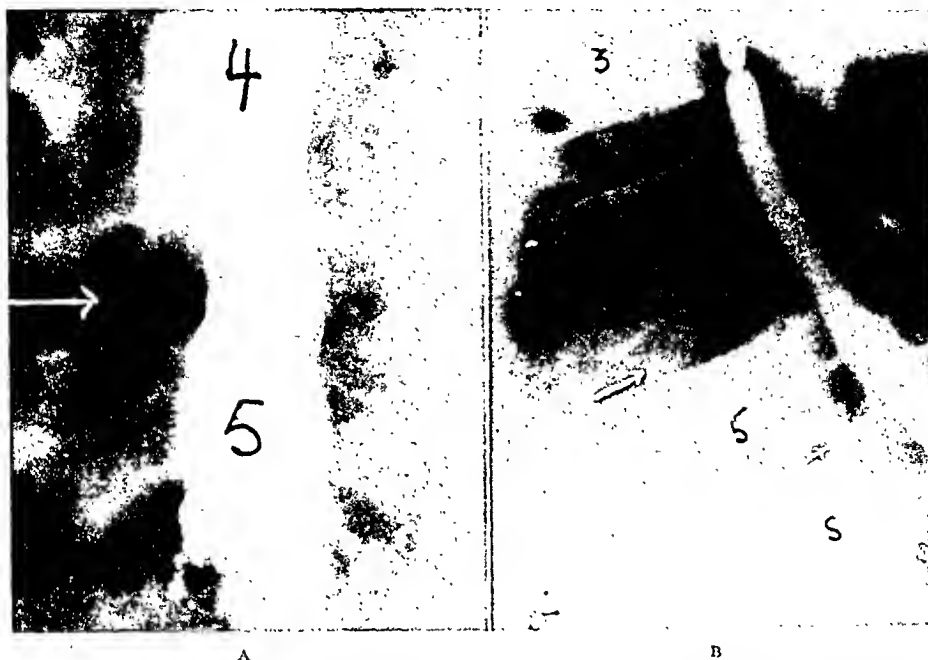


FIG. 3. Unilateral rupture of fourth lumbar disc. A, comma-shaped defect, a frequent type. Essentially the same as that shown in Figure 2, except that root structures are not so well defined. The one may change to the other during examination. B, the lateral view, shows an extradural type of indentation in the ventral surface of the lipiodol column at the disc level. It is slight because partially obscured by the superimposed lipiodol outline of the opposite (the normal) side. Note that the lumbosacral disc is narrowed, although the retropulsion involves the disc above.

most frequently involved by a ruptured disc. The prone position also brings the spine closer to the fluoroscopic screen so that visible detail and the detail on the "spot" films is much improved; and, because the convexity of the lumbar spine is downward, a smooth flow of lipiodol is obtained. By balancing the sacral curve against the tilt of the table, the lipiodol can be held in practically any area being studied.

Films are taken *even if no defect is seen fluoroscopically*. Final diagnosis depends on the changes seen in them, the fluoroscope acting principally as a guide. It is immaterial whether one starts with the patient in the upright or the partially tilted position.

Examination may also be carried out even if only a horizontal table is available, providing the patient can coöperate. He is first allowed to sit up, then quickly turns

ents—a pillow under the chest, etc.—the lipiodol can be held in position while films are obtained. A change-over switch, permitting one to take the films rapidly, is almost essential if the latter technique is employed, although one can get along without it. The same area can be studied again and again by having the patient first sit up so that all the oil collects in the lower portion of the sac. In the supine position the lipiodol usually falls into the central posterior portion of the canal, and a lesion may be overlooked. The convexity of the spine is up, so that lipiodol tends to dribble across the top of the curve as over a dam. This results in the production of a false defect in this region, and causes an undesirable breaking up of the lipiodol. This position is therefore reserved for the end of the examination. Examination of the rest of the canal, if indicated, is carried out

after the study of the lumbar region is complete. It is of the greatest importance that the area in question be filled as completely as possible. Only in this way can small defects be demonstrated, while at the same time false defects are avoided. A defect produced by a ruptured disc is constant, and is always on the side of the sciatic pain.

**Dangers of Lipiodol Injection.** Approximately one out of four patients examined will prove to be negative, so the question is frequently asked if the "oily foreign body" left in situ is not dangerous. A considerable controversy still goes on concerning this. Harkins has investigated the subject exhaustively, and concludes that there is no definite proof that iodized oil in the spinal canal is harmful; that its advantages in the diagnosis and localization of cauda equina tumors of all sorts more than outweigh its disadvantages. Those who have had considerable experience with it, Sicard, Globus and Strauss, Camp, etc., feel that it is safe. Others have had untoward experience, and do not believe in its use. A fairly severe reaction often follows the original injection. This, as shown by Lindblom, is due almost entirely to the free fatty acid in the oil. The reaction can practically be predicted from the pH, which varies even with different specimens of the same manufacture. Only fresh oil (shown by its light yellow color) should be used, and the patient should be in the hospital at the time.

Odin and Runstrom have succeeded in preparing a sesame oil preparation which they routinely use in amounts of 10 c.c. with little or no evidence of meningeal irritation. Lindblom has shown that in animals lipiodol produces immediate severe meningeal injury which lasts for about three weeks. In the animals killed beyond this time the meninges had recovered completely. He mentions the possibility of the formation of fatty granuloma if the oil is not ultimately removed. Globus and Strauss found no radiologic evidence of arachnoiditis or other pathology in patients reexamined two years after injection.

Patients studied by us with lipiodol injected many months previously usually showed very little or no increase in symptoms, or other reaction.\*

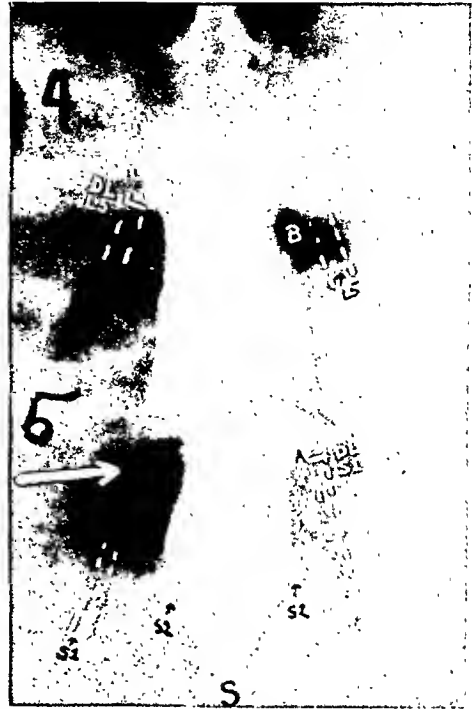


FIG. 4. Unilateral rupture of lumbosacral disc. Retropulsions of this disc may produce defects like those shown in Figures 2 and 3. Often they are much smaller and more difficult to diagnose, for reasons discussed in text. In the figure above the defect at B is a temporary phenomenon—an artifact. The defect on the left (arrow) was constant, corresponded to a large rupture. The location of its upper border along the lower margin of the lamina arch is rather characteristic. Note that the meningeal outpocketing of S<sub>1</sub> is completely obliterated on this side and that S<sub>2</sub> appears to be displaced medially. Compare with normal side.

**Lipiodol Substitutes.** Recently it has been suggested that air can be used in place of lipiodol. Such a technique has been employed in the diagnosis of spinal tumors by Dandy and by Van Wagenen, and its

\* A most conclusive contribution to this subject was recently made by Garland and Morrissey (Intracranial Collections of Iodized Oil Following Lumbar Myelography. *Surg., Gynec. & Obst.*, 70: 196, 1940). Twenty-four of twenty-five patients studied one to fourteen years after the injection of lipiodol into the subarachnoid space showed no neurologic findings which were not also present before the injection. The only exception proved to be a malingerer. In two-thirds of these cases, some of the oil was intracranial.

use was suggested in the diagnosis of cauda equina tumors by Coggeshall and von Storck. Young and Chamberlin have thus

the possibility that a lesion has been overlooked must be recognized. One cannot, however, disregard the large number of



FIG. 5. Unilateral rupture of lumbosacral disc. Note the normal meningeal outpocketing of S1 on the left. On the right it is completely obliterated by a defect which begins close to the lower border of the arch of the lamina. It corresponded to a large rupture. B, lateral view, shows a ventral extradural defect at the disc level.

succeeded in demonstrating eighteen cases of ruptured disc. Reference to the illustrations in Young's paper will show some of the difficulties involved. This method should show the larger lesions with considerable accuracy, but in the limited experience with it at the University of California Hospital it was found difficult to tell in some instances whether one was looking at a small defect or, for example, a facet superimposed on the air shadow. Fine nerve root detail is not visible by this method, but on the other hand many of the artifacts due to the nature of lipiodol are avoided. In instances where the patient or some of the consulting physicians object to the employment of lipiodol, air can be used instead, and if a definite or suggestive defect is obtained, it could be checked by lipiodol just before operation. In the event that nothing is found by the air technique,

proved cases discovered by these workers employing air alone; in careful hands this procedure may prove to be valuable.

Opaque substances of the kidney dye group have also been employed but appear to be much more irritating than lipiodol. They possess certain advantages—miscibility in the spinal fluid, rapid absorption, etc. Modifications of such radiopaque substances are being attempted, with promising results, by Aird at the University of California Hospital so as to render them useful within the spinal canal.

#### LIPIODOL ANATOMY OF THE LUMBAR SAC

The spinal cord ends in the conus medullaris at the top of the second lumbar vertebra. From its periphery arise the sensory and motor divisions of the lumbar roots. These lie in the subarachnoid space which contains the spinal fluid. The walls

of the space are formed by the delicate transparent arachnoid membrane, which acts as a lining for the thick dura. The two

that portion of the root within the sac, and "extradural" to describe the sheathed portion is therefore not anatomically accu-

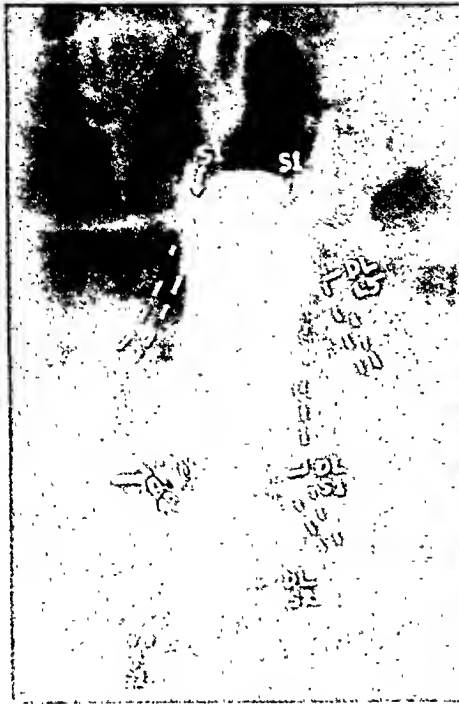


FIG. 6. Unilateral lumbosacral disc rupture. Fusion performed previously. Although the defect on the left appears small it actually involves the portion of sac normally occupied by first and second sacral roots, and was present six months after injection. Compare with normal side. Defects caused by retropulsions of the disc change somewhat with time, due to more complete filling by lipiodol, etc., but never disappear. Note phenomenon described under Figure 2.



FIG. 7. Unilateral rupture of lumbosacral disc on left. Note that area occupied by left first sacral root is sharply obliterated. The sheath of the extradural portion of this root will not fill regardless of interval between injection and injection, because of pressure exerted by the rupture. On the normal right side the sheath of the first sacral root already contains lipiodol. Note also that rupture, acting as a dam, has caused more complete filling of the lateral portion of the sac just above the defect than is present at same level on normal side. These two logical phenomena of value in differential diagnosis.

membranes are normally in contact, and are generally considered as one, so that the term "intradural" is often used when, strictly speaking "subarachnoid" is meant. The corresponding sensory and motor divisions of a root unite at a varying distance from their origin. The root then passes almost directly downward, lying against the lateral wall of the sac as it approaches the point where it will emerge from the lumbar sac. This point is marked by outpocketing in the arachnoid and dura, beyond which the meninges continue for some distance as the sheath of the root. The terminology "intradural" to describe

rate, but it is honored by usage and is employed in this paper.

The relations of the root are shown in Figure 1A. The dura has been laid back, exposing the transparent arachnoid and the contents of the subarachnoid space. It

will be noted that the root lies in immediate contact with the lateral wall of the sac as it approaches the outpocketing through

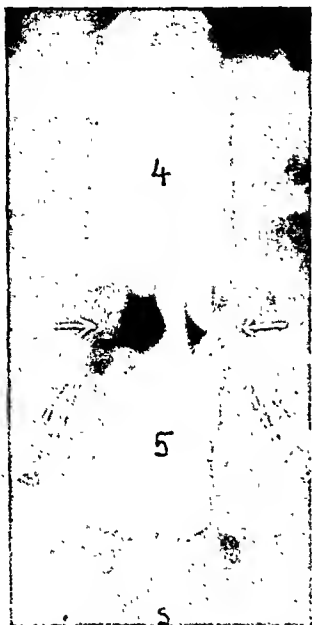


FIG. 8. Hypertrophy of the entire posterior margin of disc, involving roots in the narrow lateral portions of the canal bilaterally. Not a true rupture. Similar ring-like defects may be produced by other lesions—generalized thickening of ligamentum flavum or retraction of the disc plus thickened ligamentum flavum. A large rupture of the disc extending across the midline to involve both sides does not usually leave the central channel. Lateral view of value in differential diagnosis in these cases.

which it will leave. For this reason the portion of the sac between the root and the sac border frequently fails to fill completely with lipiodol. The portion of the outpocketing just below the root, marked A, contains no neurologic structures so it will fill readily. We have named this the “axillary pouch.” Its apex obviously corresponds to the point where the root becomes extradural. As shown in Figure 1A and in the diagram, Figure 1B, labelled correspondingly, one can draw a line *DL* across this point, and the root is then divided into

its intradural and extradural portions. This landmark can usually be identified on the iodolograms.

Hampton and the writer, in a study of autopsy material, radiographs taken after wires had been tied to the root of the cauda equina, and iodolograms taken several days or a week after the introduction of the oil (during which period the iodized oil had worked its way between the root and the lateral wall of the sac and sometimes down the sheath), found that the intradural portion of the root followed the lateral wall of the sac along the inner surface of the pedicle, and continued in contact with it after it became extradural until the intervertebral foramen was reached.

Figure 1C shows how these anatomic data may be applied to the study of the iodogram. It shows a lumbar sac filled with 5 c.c. of lipiodol, the film being taken with the patient upright. An outpouching of the lipiodol is seen at A'. Between it and the main mass is a shadow which has the appearance of a root, ending abruptly just below the pouch. On the opposite side a corresponding shadow is seen but it continues well into a lipiodol filled sheath. By drawing the “pedicle lines,” however, we obtain a picture which is anatomically correct, and as a result we can identify each root by determining into which intervertebral foramen it runs—the fourth lumbar root enters the fourth lumbar intervertebral foramen, etc.—and by the process shown in Figure 1A and B its intradural and extradural course can be established. The arrows in Figure 1C indicate streaks of lipiodol which have found their way into the lateral portion of the sac, showing that this reconstruction is correct. Asymmetrical filling of root sheaths is not uncommon, particularly if examination is performed soon after injection. This particular patient had a laminectomy on strong *clinical* indications, but nothing was found.

Having identified the roots, notice that the fourth lumbar root leaves well above the fourth lumbar disc, and hence will not be involved by ruptures at this level. The

fifth lumbar root is intradural in its course across this disc, hence it (and, if the rupture is large enough, the sacral roots medial to it) will readily be involved. Because the root is intradural, its involvement is readily demonstrable because lipiodol can be injected and the defect produced by the mass can be outlined. In the same way a rupture of the lumbosacral disc does not involve the fifth lumbar root—it leaves the canal *above* the disc—but will involve the most lateral root in the dural sac, the first sacral, (and, if large enough, the other sacral roots medial to it). Usually the rupture acts as a dam, so that filling on the side of the lesion *above* the defect is usually quite complete. On the normal side the filling may be less marked. This point is of some help in the diagnosis of difficult defects. Such “filling in” *above* the defect will be noted in practically all of the lesions illustrated in this paper.

It will be noticed in Figure 1c that the sac at the lumbosacral level is smaller than it is above; that the filled portion of the arachnoid outpocketings—the “axillary pouches”—are poorly defined, probably because these roots descend in a more vertical direction than those at higher levels; and that the first sacral root appears to become extradural somewhere between the upper and lower margin of the lumbosacral disc. The relationship of the roots to the disc at the various disc levels is fairly constant. They would lead one to expect that the lipiodol defect produced by a ruptured lumbosacral disc would be smaller than that at some higher level although produced by a mass of the same size, principally for the reason that there is less lipiodol-containing sac exposed to pressure. This has proved to be the case in many instances. Other features which differ from those at the fourth lumbar disc are: (a) the shape of the bony canal and (b) the sacral lordosis, so that in the anterior posterior view the lower part of the sac is seen somewhat on end. It is therefore foreshortened and will be projected through the body of the fifth lumbar vertebra. This must be

kept in mind in looking for defects at this level.

It might be supposed that it would be possible for a ruptured *lumbosacral* disc to involve only the small *extradural* portion of the first sacral root. However, absence of a defect at this level has never been noted in any operatively proved case which has come to the attention of the author, those so termed showing small defects which had been overlooked.

#### TYPICAL DEFECTS PRODUCED BY RUPTURES

A typical rupture is a discrete circumscribed mass projecting from the posterior margin of the disc to one side of the midline; not infrequently it is loose. The mass is ventral to the dura and therefore produces a ventral, extradural pressure defect of the sac. Lipiodol cannot enter the local area. The root or roots are pushed almost directly backward against the facets which overhang the canal. Inman and Saunders have shown that the disc in front and in the ligamentum flavum behind (which fuses with the joint capsule), ordinarily leaves a groove barely large enough to contain the lateral part of the dural sac and the single nerve in it, so that a slight enlargement of either should readily wedge this root between them within the spinal canal—that this (not the intervertebral foramen) is anatomically the most likely point for root compression. Since the posterior longitudinal ligament is defective laterally, a rupture of the disc tends to take place to one side of it rather than in the midline. This has been noted by Middleton and Teacher, Elsberg, Dandy and others. Even when the rupture is large it apparently starts to one side. In a large group of iodolograms it is possible to select all degrees of defect from the minute ones involving one root to large ones showing complete block obstructing the entire canal. This was illustrated in the paper by Hampton and the writer.

Figure 2A shows the appearance of a unilateral rupture of the fourth lumbar disc after laminectomy and the removal of

the ligamentum flavum have partially decompressed the lesion. The dura has been incised and laid back. The bulge seen in the floor of the dura is caused by the extradural mass formed by the ruptured disc. The iodogram, Figure 2B, shows a corresponding defect. Practically all the structures seen in one can be identified in the other. It will be noted that the defect extends for some distance below the disc. This is to be expected as the pressure at the disc level will produce a certain degree of wedging of the roots in the lateral portion of the canal below. The defects produced by the root shadows are not always so sharply outlined as in this instance.

Figure 3A shows a "comma" defect—a frequent type. It is similar to that Figure 2B except that the root shadows are not so clearly distinguishable. Note that in the lateral view (Fig. 3B) a barely perceptible indentation is visible, principally because the lipiodol from the normal side covers the defect produced by the rupture. For this reason the greatest dependence is placed on the anteroposterior views, in which the entire obliterated area may be seen. Oblique views sometimes show a defect slightly better than the antero-posterior ones, but on the other hand, may be quite misleading. A slight normal bilateral waist-like constriction, sometimes seen in the anteroposterior views, or the indentations seen in the lateral view produced by the slight posterior bulging of the normal disc, may appear like an anterolateral defect in the oblique views. Taken in conjunction with the anteroposterior view, however, these additional views are of value, particularly in differential diagnosis. (Note also on Figure 3B that although the lesion is at L<sub>4</sub>, the lumbosacral disc is the one which is narrowed.)

Ruptures at the lumbosacral disc may have the same appearance as those at the fourth disc level; often, as we have said, the defects are smaller. These small defects are of great importance because they may be overlooked. Figures 4, 5 and 6 show three typical examples. In Figure 4 the defect at

B may be disregarded because it was a purely temporary finding—an artifact. The arrow on the left points to what appears to be a rather high "axillary" arachnoid outpocketing. Its lower edge is visible just beneath the dark area formed by the arch of the laminae. The sac below this point, together with a root in it which may be faintly seen (S<sub>2</sub>), appears to be slightly displaced medially. On the opposite (the normal) side, the outpocketing is at a lower level. This difference was not due to a variation of the anatomic site of emergence of the roots, which probably never occurs, but to a defect produced by a large ruptured disc. The arachnoid pocket on the left is entirely obliterated; the lower margin of what *appears* to be it is really the upper margin of the defect.

Figure 5 on the left shows an indentation of the sac. On closer inspection the entire arachnoid pocket is seen to be obliterated in much the same way as in the case shown in Figure 4. In the latter the defect was overlooked preoperatively. In the former it appeared questionable. In both instances large ruptures were found at operation. The high upper level of these defects is probably due to the more or less horizontal position of the sacrum so that the defect is projected through the outline of the vertebral body. The lateral view (Figure 4B) shows the defect at the disc level.

Figure 6 shows normal filling on the left. On the right, not only is the portion of the sac occupied by the first sacral root obliterated, but that occupied by the second sacral root. This patient had previously had a fusion. At operation a small rupture was found. Defects of this type: (a) those in which the root appears pinched off just beneath the lower border of the arch of the lamina, and (b) those in which the arachnoid outpocketing is obliterated and there is a slight medial displacement of the border of the lipiodol column—are not uncommon at the lumbosacral (L<sub>5</sub>) disc level. One defect may change into the other, if the patient is examined a second time; during the interval, the



lipiodol fills in around the roots. The defect, however, never entirely disappears, regardless of the period between examinations, whether this is a day or a year. In cases reexamined as much as six months and a year after the initial study, complete "filling in" of the first sacral root sheath was noted on the *normal* side, none whatever on the side of the defect at any time. Figure 7 illustrates this characteristic. This is of definite confirmatory value. However, one should not confuse such changes with the temporary failure of one sheath to fill, like that noted in Figure 1c, a normal iodologram. In that instance the arachnoid pockets were visible at the same level on both sides; and undoubtedly if the patient had been reexamined at a later date, uniform filling in the sacral sheaths would have been bilaterally present.

Films at varying periods after the injection are very helpful if one has the earlier iodolograms to compare them with; otherwise they may be difficult to interpret—root shadows become more prominent, the lipiodol may form droplets, etc. However, the addition of more lipiodol is rarely necessary for reexamination—the old usually suffices.

Comparison of the normal side with that in question, particularly of the visible portions of the arachnoid outpocketings, is of great importance in the recognition of small defects at any level.

#### DIFFERENTIAL DIAGNOSIS

The criteria employed in differential diagnosis are based on the same principles as those constantly employed by roentgenologists in studying the gastrointestinal tract. Their application to the diagnosis of spinal cord lesions, i.e., determining whether they are intradural or extradural (and if above the cauda equina, intramedullary) have been described by Peiper, Odin and Runstrom, Camp and others. When one makes a diagnosis of "posterior ruptures of the disc," one is really diagnosing a ventral extradural tumor at the disc level. Since true tumors fitting this descrip-

tion, particularly unilateral ones, are not often encountered, the specific diagnosis is usually justified.

In the anteroposterior view, one cannot always be certain that he is not dealing with the intrinsic defect of an intradural tumor, rather than the extrinsic pressure defect of an extradural lesion—extradural tumor or ruptured disc—particularly if the defect is large. In the case of an intradural lesion the lipiodol will closely fit the mass, and a sharply defined filling defect is visible in *every* view, particularly that which shows it in silhouette. On the other hand, if the defect is due to a mass outside the dura, the en face defect (shown by the anteroposterior or postero-anterior views if lesion is ventral or dorsal) will be sharp where the walls of the sac and the roots are forced in contact with each other. The silhouette view will be similar to that of any flexible tube which has been indented from the outside. Of course if the obstruction is complete only the upper portion of the indentation is shown. The same is sometimes true if the lateral view is taken in the upright position—the lipiodol may be held up above the defect but fail to fill the region just below it.

Considerable attention has recently been directed toward the rôle of hypertrophies of the ligamentum flavum in the production of disability of the same sort resulting from ruptures of the disc. Most of this work has been done by the group at the University of California, and the subject has been discussed in detail by Naffziger, Inman and Saunders, and by Brown. These writers have placed the subject on a sound pathologic basis. Through their kindness, and that of Dr. Stone of the Division of Roentgenology, the author has had the opportunity of studying the anatomic preparations and the iodolograms. These are illustrated in the recent reports by Brown. The lipiodol defects shown in his papers are characteristic of the type to be expected. Those which are caused by unilateral scars are usually indistinguishable from the defects produced by ruptured



disc. In three cases a ruptured disc was also found, so it is not known which lesion was responsible for the defect. In two others only thickening of the ligament was found. Abbott reported a case of operatively proved local hypertrophy of the ligament. The defect was quite similar to that of a ruptured disc, and the specimen shows a circumscribed mass of degenerated ligamentum flavum of the shape one would expect to produce this type of defect. Theoretically one should see a posterior indentation in the lipiodol column in the lateral view, but usually this is not visible, either because obscured by lipiodol in the rest of the sac, or, not infrequently, because of technical difficulties.

Hypertrophy of the ligament produces symmetrical, bilateral, usually sharply defined defects, leaving a central clear channel, because the central area, being wide, is not completely encroached upon. In the posterior views an indentation may be seen in some instances.

In three cases studied by Hampton and the writer thickened ligament was found at operation in association with ruptures of the disc. In one of these there was complete block, in another a complete ring-like defect and in the third the defect was similar to that which would have been produced by the ruptured disc present, and could have been ascribed to either lesion. Smooth, particularly multiple, constrictions of an hourglass type, unless marked, and *proved to be constant*, must be interpreted with caution. They are a normal phenomenon in the thoracic region and in other areas merely represent stringing out of the lipiodol column, particularly when the sac is quite wide. This also applies to very slight symmetrical defects, rather sharply defined, sometimes seen at the disc level, particularly if the root makes a strong outward curve as it leaves the sac. Perhaps these are due to slight hypertrophies of the discs as a whole, or to slight thickenings of the ligamentum flavum, but in two operated cases nothing definite was found. It is, of course, possible, as has been

suggested by Brown, that in such cases thickened ligament was removed with a lamina and was therefore overlooked.

The association of thickenings of the ligamentum flavum with retropulsions of the disc suggests that thorough exploration should always be carried out at operation in order definitely to exclude the presence of a disc lesion before it is concluded that disability was caused by ligamentous hypertrophy, especially when lipiodol shows a unilateral defect and no corresponding localization of the thickening is observed. Elsberg found only one ruptured disc ("ecchondrosis") in his first hundred laminectomies for spinal cord tumor, but there were fifteen in his second hundred, after he had learned to look for them. Yet he was dealing almost exclusively with the large protrusion producing obvious neurologic changes. When the lesion is small it may take a careful search to find it, and often the removal of the facet is necessary to expose it. This has been reemphasized recently by Mixer.

Sometimes there is a generalized hypertrophy, fibrous or ossific, of the entire posterior disc edges so that it protrudes into the canal, obliterating the narrow lateral portion completely. This is not a true rupture of the disc, but rather a generalized hyperplasia. The defect may be exactly similar to that produced by generalized thickening of the ligamentum flavum or of rupture of the disc in association with thickening of the ligament. If a definite pressure defect is visible anteriorly in the lateral view, a partial differential diagnosis is possible. One should be certain that the view is a true lateral one, as one of the bilateral defects can be made to appear anterior or posterior if rotated a few degrees.

The defect illustrated in Figure 8 could be interpreted radiologically as due to generalized thickening of the ligamentum flavum, to rupture of a disc plus thickened ligament, or as generalized hypertrophy of the disc margin. It turned out to be the latter.

Uncomplicated ruptures of the disc do not usually give these symmetrical defects with a central channel, because they lie more on one side than on the other. The lipiodol column usually passes by on one side, unless the rupture is so big that the entire canal is obliterated. Single and multiple defects in the lipiodol column are sometimes due to arachnoiditis. These defects do not correspond to disc levels except accidentally. When they do, they may be indistinguishable from the defect of a ruptured disc, although theoretically they should give an intradural type of defect in the lateral view. Defects due to multiple ruptures of the disc have been observed only once by the writer. Camp, however, has described several.

One of the interesting sidelights of the work on posterior protrusions of the disc has been the discovery that lesions such as extreme arachnoiditis (usually in connection with a history of severe trauma), or hypertrophy of the ligamentum flavum are a not infrequent cause of a similar clinical syndrome.

Occasionally lipiodol is injected extradurally through an error in technique, and results in a bizarre iodogram. The lipiodol, however, does not move during fluoroscopy, and within an hour or so much of it has found its way through the intervertebral foramina into the soft tissues. No ill effects were noted in the cases observed in which such an error was made. In one instance lipiodol which had remained freely movable in the canal over a period of several months suddenly became extradural after a spinal puncture.

#### SUMMARY AND CONCLUSIONS

The iodographic method of determining the presence within the spinal canal of the ruptured portion of an intervertebral disc is quite accurate. Iodography is a particularly valuable procedure in the diagnosis of small lumbar lesions because these are associated with a syndrome so closely resembling that of low back strain, sacroiliac disease, or "sciatica" that it is

difficult to differentiate among these conditions otherwise.

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# ULNAR NERVE PARALYSIS COMPLICATING FRACTURE OF THE MEDIAL EPICONDYLE OF THE HUMERUS\*

JOSEPH I. ANTON, M.D., F.A.C.S.

AND

GEORGE B. REITZ, M.D., F.A.C.S.

Associate Attending Surgeon, Cumberland and Beth-El Hospitals

Attending Surgeon, Cumberland and St. Johns Hospitals

WITH THE COLLABORATION OF

JULIUS SADER, M.D.

AND

MILTON B. SPIEGEL, M.D.

Assistant Surgeon, Cumberland Hospital

Assistant Surgeon, Cumberland Hospital

BROOKLYN, NEW YORK

THE syndrome of ulnar nerve paralysis complicating fracture of the medial epicondyle of the humerus has received scant notice in medical literature. In 1929 Cotton<sup>1</sup> reported three cases upon which he had operated and mentions having seen a dozen cases in all. During the past few years a flood of literature on this topic has appeared, as if to make up for lack of recognition in years gone by. A review of the literature reveals that the incidence of nerve complications in fractures and dislocations of the elbow is very low, despite the fact that the elbow provides the majority of dual injuries of bone and nerve.

The nucleus of the medial epicondyle of the humerus appears at approximately the fifth year and fuses at about the eighteenth year. The extent to which the epiphysis is intra-articular varies. Attached to the epicondyle are the anterior and posterior portions of the ulnar collateral ligaments of the joint capsule, and the common tendon of the superficial muscles of the forearm. These serve to pronate the forearm, flex the wrist and fingers, and aid in flexing the elbow.

The ulnar nerve, due to its anatomic position in the postcondylar groove, is especially vulnerable. As it passes down in the interval between the olecranon and the medial epicondyle, it is closely bound down

by deep fascia. After hooking around the medial epicondyle, it passes out between the two heads of the flexor carpi ulnaris, along the medial side of the ulnar collateral ligament of the elbow.

Nerve lesions are seen almost exclusively in supracondylar or epicondylar fractures of the humerus and in dislocations of the elbow joint. Dislocation is not infrequently accompanied by fracture of the medial epicondyle, or, in children an ablation of the isolated epiphysis.

## MECHANISM

A dislocation of the elbow, either posteriorly or posterolaterally, may be caused by a fall on the hand with the elbow in slight flexion and the forearm abducted. This may cause an avulsion of the medial epicondyle by means of the force exerted by the firmly attached flexor tendon and the ulnar collateral ligament. These tend to pull the fragment down and forward away from its attachment to the humerus, sometimes twisting it end over end and rotating it.<sup>13</sup> As a result of this dislocation of the os ulnae with its muscles and ligaments posteriorly, the fragment is carried backward and laterally, so that it lies anterior to the semilunar notch but posterior to the trochlea.

In the course of reducing a dislocation of the elbow, forceful abduction may, in

\* From the Traumatic Surgical Service, Cumberland Hospital.

addition to producing an epicondylar fracture, cause a contusion or stretching of the ulnar nerve leading to some degree of ulnar involvement. It is our opinion, and the same view was hinted at by Cotton, that such epiphyseal fracture of separation may be the result of awkward, incompetent, forceful and overenthusiastic reduction of a dislocation of the elbow joint. With manipulation, the separated epicondyle, lying behind the trochlea and in front of the semilunar notch, may drop or be forced into the notch as the humerus slides forward. The epicondyle may thus be locked within the joint proper, carrying with it the insertions of the flexor muscles, the ulnar collateral ligament, and the ulnar nerve, the latter by means of fibrous tags stretching from the wayward epicondyle to its former bed. The nerve thus may be stretched, constricted by fascial bands, or crushed between the bony surfaces.

Statistics on the incidence of this lesion are few. In a recently published tabulation<sup>3</sup> of 4,390 cases of fractures and dislocations treated by the Fracture Service of the Massachusetts General Hospital, fractures or separation of the medial epicondyle occurred twenty-seven times (.006 per cent). Eight of these complicated dislocation of the elbow, of which four showed evidence of ulnar nerve paralysis. Platt,<sup>6</sup> in a review of 919 fractures and dislocations about the elbow joint, noted 166 fractures of the medial epicondyle. Of these only twenty-two showed the epicondyle in the joint. Of the twenty-two cases of epicondylar inclusion, the ulnar nerve showed some evidence of primary injury in seventeen. In two cases it was discovered at subsequent operation that the nerve had entered the joint itself, along with the epicondyle. Our own case reported below is of that unusual variety.

Olmos<sup>9</sup> demonstrates the predominance of this lesion among children in a review of forty-two cases of ulnar nerve paralysis in fractures about the elbow, giving the following table of age incidence:

	No.
Up to 6 years of age.....	8
6 to 11 years of age.....	10
11 to 16.....	6
16 to 20.....	4
20 to 25.....	5
25 to 30.....	1
30 to 40.....	3
40 to 50.....	2
50 to 60.....	1
60 to 65.....	2

#### DIAGNOSIS

Cotton blames the failure to recognize an ulnar nerve involvement upon the satisfaction of the manipulator in getting the dislocation reduced, with the omission of any detailed examination afterward. The possibility of this particular lesion should be kept in mind in treating a supracondylar fracture of the humerus or a dislocation of the elbow, especially when it occurs in children, since this is essentially an injury of childhood. The carrying angle may be increased and the medial epicondyle cannot be palpated in its proper place. There is limitation of flexion and extension, and some degree of ulnar nerve involvement may be demonstrated. Routine roentgenograms should be taken before reduction, but it is imperative that they be repeated afterwards.

In considering the diagnosis of this syndrome, the following points are stressed:

1. Age incidence: in all elbow fractures in children, this possibility should be borne in mind.

2. The usual signs of ulnar nerve involvement, paralysis, paresis, anesthesia or paresthesia, wasting, etc.

3. X-ray findings: (a) absence of the medial epicondyle from its anatomic position; (b) visualization of the fragment within the joint; (c) medial widening of the joint space. It is advisable to compare the injured elbow with the normal side.

#### TREATMENT

Since many of these cases follow over-ardent manipulation in attempted correction of a dislocation of the elbow, a minimum of manipulation is recommended.

Where the medial epicondyle has been fractured or separated, the fragment is sometimes turned end over end, due to a

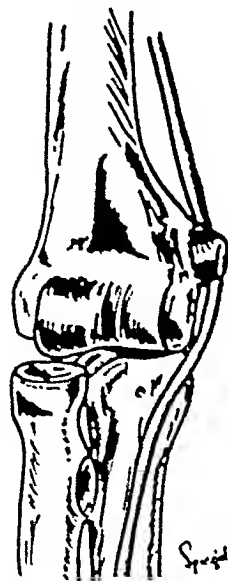


FIG. 1. Normal anatomic relationship of the ulnar nerve to the (unfused) medial epicondyle.

strong muscle pull. Such cases are impossible to reduce by closed manipulation, and open reduction must be resorted to. When roentgenographic studies reveal that the fragment is not within the joint itself, an attempt at closed reduction should be made, keeping in mind the possibility of ulnar nerve involvement. If this attempt fails, an open reduction should be done as soon as feasible.

In cases where the medial epicondyle has entered the joint, three different methods of replacement have been devised. Fèvre and Roudaitis<sup>10</sup> advise abduction of the forearm in extension and supination, longitudinal traction in the axis of the arm, and flexion of the forearm with or without transitory movements to the inside. Zadek<sup>11</sup> reports closed reduction by increasing the carrying angle and then applying traction with digital pressure over the head of the radius. Sehmi<sup>12</sup>, on the basis of anatomic and kinesiological knowledge that the superficial flexor muscles of the forearm originate from the medial epicondyle by a common tendon, felt that if tension were applied to these muscles, the

interposed fragment might be dislodged from the joint by the muscle pull upon it. Accordingly, under anesthesia, the forearm

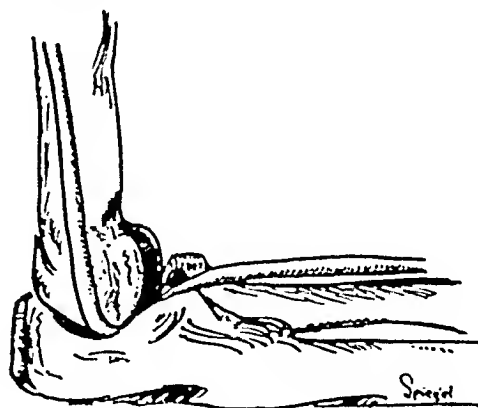


FIG. 2. Condition observed on operation, with the ulnar nerve dipping into the elbow joint, compressed between the olecranon and the trochlea.

is slightly supinated, the wrist, fingers and elbow extended, and the forearm slightly abducted to increase the gap between the trochlea and the ulna. No more abduction is employed than is ordinarily used in an open reduction. Sehmi<sup>12</sup> believes that no further damage can be done to the nerve. It is our opinion that manipulation, if carried out soon after the injury, may displace the epicondyle from the joint, but it will not replace it and further injury may be done to the nerve.

We advocate early operation as soon as nerve involvement is appreciable, or, whenever the fractured fragment is in such a position that it can not be properly replaced with minimum manipulation. When the epicondyle is widely separated or comminuted, it should be excised with anterior transposition of the nerve whether or not paralysis is present.<sup>5</sup>

The incision is made along the inner side of the elbow. The nerve is exposed and, in epicondylar inclusions, is carefully dissected from above downward to the point where it enters the joint. The flexor muscles are then identified and with the elbow in abduction, traction is made on the flexor muscles and the fragment is released from the joint. The ulnar nerve is then transposed to the anterior aspect of the forearm. It is sometimes necessary and

usually expedient to excise the superfluous epicondyle. Where the fragment is large enough, it may be fixed by means of a wire

The elbow was swollen, tender, and painful, was held at right angles, with limitation of all motion. The x-ray revealed a fracture through



FIG. 3.



FIG. 4.

FIGS. 3 AND 4. Roentgenographic (preoperative) study, showing the absence of the medial epicondyle from its proper position. A widening of the mesial portion of the joint space, and the fragment displaced downward and forward to the joint.

nail. Growth disturbance, because of the excision or internal fixation, is of no clinical importance.<sup>13</sup> The common flexor tendon is either sutured to the periosteum or to the humerus through a drill hole. In all operative procedures for avulsion of the medial epicondyle, whether nerve involvement is apparent or not, the ulnar nerve should be transposed anteriorly to avoid injury either from the roughened epicondylar bed or from fibrous tissue stimulated with healing.

#### CASE REPORT

J. H., male, 14 years of age, was seen at the Out-patient Department on September 9, 1937, with his left arm immobilized in a Velpeau dressing. He had fallen on his elbow the day previous, and at a nearby hospital under general anesthesia his elbow was manipulated and immobilized. He was told that he had had a fracture-dislocation, but no roentgenographic study had been made.

the internal epicondyle with displacement and rotation of the epiphyseal nucleus.

On November 1, 1937, evidence of ulnar nerve involvement was noted and the boy was admitted to the hospital. Tenderness was elicited at the site of the epicondyle, but the epicondyle could not be felt. The carrying angle was increased. Extension was limited to 110 degrees and flexion to 70–80 degrees. The hypothenar eminence and lumbricales were atrophied. The fifth finger was maintained in flexion with loss of ability to extend at the interphalangeal joints. There was loss of sensation from about 1 inch above the ulnar styloid down to and including the fifth finger and the inner half of the fourth finger. Roentgenograms on November 4 revealed an injury to the center of ossification of the medial epicondyle, which was displaced downward and forward, lying in the elbow joint internal to and in front of the trochlea. (Figs. 3 and 4.)

Open operation was done because of the ulnar paralysis. A curved incision was made following the ulnar groove, passing in a line

from a point 3 inches above the medial epicondyle to 3 inches below the groove. The ulnar nerve was exposed in the upper part of the incision lying on the inner head of the triceps, and was traced downwards to the groove behind the internal epicondyle, dividing the fascia along the posterior border of the nerve. Similarly the distal portion of the nerve was dissected upwards, with care not to injure the branches to the flexor carpi ulnaris.

The ulnar nerve was found to dive under a fibrous arch, pulled over so that it was lying between the trochlea and ulna, compressed between the two articular surfaces. (Fig. 2.) The nerve was released by severing the fibrous band, and then was transplanted anteriorly into a new bed formed by cutting the humeral head of the flexor carpi ulnaris about  $\frac{1}{2}$  inch below the medial epicondyle. Because of the fact that the patient had a range of motion sufficient to carry on his usual necessary functions, this procedure was deemed adequate. The severed muscle ends were approximated, deep fascia overlapped, and the wound closed. The forearm was immobilized at right angles to the arm. The wound healed and the patient was discharged.

On May 27, 1938, a follow-up examination showed normal pronation, very slight limitation of supination. Extension was increased 25 degrees over the preoperative status to 135 degrees and flexion increased about 35 degrees to approximately 40 degrees. There was still some residual wasting between the metacarpals, and extension of the fifth finger was limited to about 65 degrees. At the site of previous anesthesia sensation had improved somewhat, so that only mild paresthesia and diminution of sensibility to warmth remained.

On October 10, 1938, eleven months after the operation, the patient showed a further improvement of extension to 150 degrees, while flexion was but 5 degrees less than on the normal side. There was a full regeneration of the ulnar nerve demonstrated by a complete return of all sensation and the ability to extend the fifth finger fully. This agrees with the estimation of Tinel<sup>14</sup> that the average period

for the regeneration of the ulnar nerve is ten to sixteen months.

#### SUMMARY

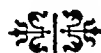
1. A typical case of ulnar nerve paralysis complicating fracture of the medial epicondyle or the humerus is presented and statistical incidence and literature on the subject is reviewed.

2. The anatomy of the part is reviewed and the mechanism of injury is explained.

3. A plea is made for careful examination and an early operative release of the ulnar nerve from its position and compression.

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# THE TREATMENT OF DUPUYTREN'S CONTRACTURE\*

HENRY W. MEYERDING, M.D.

Section on Orthopedic Surgery, The Mayo Clinic

ROCHESTER, MINNESOTA

IN 1832, Dupuytren,<sup>1</sup> a French surgeon, described a flexion deformity of the fingers resulting from shortening and thickening of the palmar fascia. Attempts to straighten the fingers by extension, by the application of ointments and by massage were carried out in the hope of resolving the contracting mass, but they proved to be useless. Dupuytren said: "A person attacked by this infirmity attached to his finger a weight amounting to 150 pounds (68 kg.), without influencing in the least the degree of the flexion." Operative treatment therefore became recognized as the method of choice, especially with the advent of aseptic surgery. Koch,<sup>2</sup> in 1933, considered that Dupuytren's contracture is a surgical condition; Sir William Ferguson,<sup>3</sup> in 1842, had stated: "The fascia should be dissected out at once."

In 1882 Bellamy<sup>4</sup> said: "... as I thought the tendon was uninvolved, and still ran in a tolerably free theca, I divided the bands with a von Graefe's iridectomy knife, which is singularly useful for fine plastic work, and extended the fingers forcibly. No good came of this proceeding. I subsequently placed him (the patient) under an anesthetic, and carefully and thoroughly extirpated the entire cicatricial tissues, and divided the tendon, with antiseptic precautions. The finger was carefully retained in the straight position, a metal circlet was made for the wrist, and a piece of stout steel clock-spring welded to it. This steel spring was carried up the dorsum of the finger and suitably attached to it. By its tension it effectively kept the parts on the stretch and when the wound had healed, passive and active movements, conducted by the patient himself, brought about an excellent result." In 1920, Men-

nel<sup>5</sup> wrote: "Dupuytren's contracture can, I firmly believe, be prevented from causing deformity if the trouble is detected early enough, and the patient is instructed to perform for a few minutes twice daily the exercise of hands clasping and turning, spaced with a little deep kneading of the palm. Otherwise, when the deformity is fully established, no physical treatment seems to be really effective." In 1929, Jones and Lovett<sup>6</sup> said: "In the early stages, exercise designed to hyperextend the fingers should be prescribed. The patient should be instructed to stretch the contracture regularly. Operative measures are required when the deformity is more marked." In 1932, Davis<sup>7</sup> expressed the opinion that delaying operation unfortunately results in extreme contracture, "making impossible complete eradication of the diseased tissue and permitting the secondary changes in the skin and joints which are so frequent causes of recurrence." In 1933, Wolf<sup>8</sup> said: "It is obvious that no form of physiotherapy can affect scar tissue."

In discussing the after-treatment in cases of Dupuytren's contracture, some authors recognized the need of careful splinting and physical therapy. According to Jones and Lovett, if the operation of subcutaneous division by multiple punctures is performed the after-treatment should consist of the early use of active movements and regular stretching. They also said that prolonged splintage will defeat the object of this simple operation. They expressed the opinion that the operation of open dissection and removal of contracted bands is frequently indicated. The treatment employed after this operation presumably was the same as that

\* Read before Western Section, American Congress of Physical Therapy, Los Angeles, California, June 9, 1938.

employed after the operation of subcutaneous division by multiple punctures.

Smith,<sup>9</sup> in 1884, said that the treatment of choice is operation upon the contracted bands of fascia. He did not agree with the recommendation that many incisions should be made; he said that as few incisions as possible should be made. The object of this treatment is to separate the cut parts as much as possible, in order that the contracture will not recur.

Reeves,<sup>10</sup> in 1885, recommended complete excision of the contracted tissue rather than subcutaneous division. After the operation he put the hand in a long back splint for the forearm and hand; the fingers were fully extended. The bandages were relaxed in twenty-four hours; they purposely had been applied somewhat firmly, in order to maintain full extension. "The wound healed by first intention, and within three weeks my patient could play the piano, write letters, and so forth." In 1890, Macready said: "It is necessary to observe the difference in the after-treatment between the palmar and the phalangeal cases. The palmar can be treated throughout with the ordinary soft metal splint, bent to the fingers and gradually extended. The phalangeal cases, however, are best treated by the aid of a dorsal splint with rack and pinion movement over the finger-joints. . . . It is quite possible to obtain complete success, even in severe cases, by using the simple metal splint on the palm but not without much diligence and constant attention on the part of the surgeon. In all cases, extension should not be made at once or pain is produced. After division of the bands and straightening of the fingers, they should be allowed to resume their flexed position before the soft metal splint is adapted. Extension, whatever apparatus is used, should not begin till four or more days have elapsed, and should be continued for a week or more after full extension of the fingers has been accomplished."

Adams<sup>12</sup> read a paper on this subject at a meeting of the Medical Society of London

in 1890. A report of this meeting contained the following statement: "Mr. Adams still used the steel instrument fitted to the dorsal aspect of the hand with prolongations along the contracted finger or fingers, having joints corresponding to the phalangeal articulations, movable by rack and pinion joints in all cases of phalangeal contraction. In cases of simple palmar contraction this might be dispensed with, and a padded metal splint capable of being bent to any curve and altered from day to day might be applied. Mechanical extension should be maintained for three weeks, night and day, allowing only a little passive movement, and then gradually discontinued during the day but maintained at night for several months, by a simple form of retentive splint." In 1931, Manson<sup>13</sup> reported that this condition affected four members of one family, a father and three sons. There was no history of gout in this family. Manson said that the hereditary, environmental and senescent factors were difficult to evaluate as the deformity usually developed late in life and many persons died before it developed. In 1931, Trumper<sup>14</sup> reported a case in which he thought chopping wood was an etiologic factor and expressed the opinion that the patient obtained benefit from application of an ointment.

In 1931, Powers<sup>15</sup> reported a case in which scleroderma was a complication. According to this writer, after the original report on Dupuytren's contracture in 1832, the first important contribution on the subject was not made until 1902. Powers expressed the opinion that in cases in which the contracture is associated with pulmonary disease it is the result of irritation of the inferior cervical and first thoracic ganglions, which are situated directly behind the pleura.

In 1932 Desplas and Meillère<sup>16</sup> reported eight cases in which the palmar fascia was resected by making two lateral incisions and raising the intervening flap. In a discussion of this report, Fredet<sup>17</sup> suggested that the excellent results obtained by these

authors could not be attributed to the method of treatment as an early stage contracture was present in all of the cases. Fredet agreed that not only the palmar fascia but also the lateral digital extensions must be cut if a successful result were to follow. He said that the technique employed by Desplas and Meillère was satisfactory in cases of early contracture but that it did not provide sufficient exposure in cases of advanced contracture. According to Fredet, the skin grafting operation that has been advocated by Paul Berger, although rarely indicated, has a place in the treatment of Dupuytren's contracture.

Moure,<sup>18</sup> in discussing the same paper, said that the most important part of the procedure was to excise as much of the involved skin and fascia as possible. To do this he used an incision which was begun at the ulnar side of the fifth finger and extended transversely across to the median line of the heel of the hand at the level of the lower border of the annular ligament. In cases in which the middle and index fingers were involved he made a second incision along the radial side.

In 1932, Davis<sup>7</sup> reviewed thirty-one cases and said that the etiology was obscure. He said that fibrolysin, radium therapy and Roentgen therapy are useless, but that fascial excision, fascial excision and skin graft, and subcutaneous fascial division are beneficial in certain cases. In 1932, Noica and Parvulescu<sup>19</sup> expressed the opinion that the contracture is due to injuries to the eighth cervical and first thoracic nerves and cited cases from the literature in which the arthritis, bullets, hematomyelia, and so forth, seemed to be the exciting factors. They reported two cases in which syphilis, and one case in which a lesion in the region of the eighth cervical and first thoracic roots, produced a bilateral deformity of the hands.

Jelliffe<sup>20</sup> said that certain unconscious grasping tendencies were transmitted to embryonic tissues and persisted in the palmar fascia of certain persons. He expressed

the opinion that this might be a factor in the development of the contracture. Power<sup>21</sup> said: "Dupuytren's contracture is not an isolated condition and not a clinical entity, but usually an effect of past, or present visceral disease, producing irritation of the sympathetic system." In his earlier paper,<sup>15</sup> he said, "While I have little personal knowledge of the various modes of physiotherapy, I believe that they should be tried with the definite objective of depressing the inferior cervical and the first dorsal sympathetic ganglia, and combined with conservative local surgery if necessary. I feel that sympathectomy should be resorted to only when the pain cannot otherwise be relieved." In his more recent article,<sup>21</sup> he said: "It seems possible that conservative surgery, even when signs of sympathetic irritation were present, might give permanent results, if followed by parathyroid treatment." According to Koch,<sup>2</sup> protection of the digital nerves deserves attention. Davis<sup>7</sup> said: "The radical operation of excision of the diseased fascia with immediate skin suture yielded very disappointing results . . . as high a percentage as 20 were definitely worse. This last figure is made up entirely of cases showing perfect anatomic results, yet functionally ruined by scar tenderness and finger anesthesia. The cause of failure in these cases is apparently inclusion of a digital nerve in the scar underlying the suture line, or possibly subsequent massage on the dissected nerve, which, denuded of its protective covering, resents unaccustomed pressure. . . . Massage, manipulation, extension, hot-water baths, passive hyperemia, ionic medication, and counter-irritation have been tried for generations without effect, although occasional successes have been claimed following their employment." In considering the post-operative treatment the author said: "Continuous splinting for a week is adapted, followed by massage and manipulation with night splint only for a further month."

It has been my experience that many patients who have Dupuytren's contracture do not consult the surgeon during the early stage of the disease and, as a rule, are not seriously concerned until the deformity becomes obvious to their friends or interferes with their work. In many of the cases of Dupuytren's contracture which have been observed at the Clinic the condition was discovered in the course of a general examination for other symptoms and when the patients were advised as to treatment they have not seemed to be seriously impressed as to the necessity of proper measures to relieve the contracture; on the other hand, in some cases the patients have not come for examination until the deformity has reached such a degree that only the most radical surgical treatment is of any avail. I have observed such a case in which the deformity had been present twenty-five years; the hands had become macerated and a foul odor was present; at the time this patient was examined at the clinic he wished to be assured that the operation would guarantee a perfect result. The condition had already produced contracture of all the fingers and of the thumbs and the patient constantly employed a handkerchief to wipe the macerated region. Needless to say, we could not give the patient such preoperative assurance.

At the Clinic we have observed a great difference in the rapidity of progress of the disease and also have noted that for some unknown reason the progress of the deformity is often arrested and it may cease to increase for many years. In some cases the early stages of the contracture are unattended by local soreness or redness, and signs of inflammation are absent; in other cases definite tenderness and swelling, some local redness and possibly a local increase in temperature are noted. The region first involved is the palmar aspect of the metacarpophalangeal joint of the ring finger. Repeated trauma to this region is a very common occurrence; when such trauma is associated with some toxic

irritant that acts systemically it may produce irritation of the palmar fascia and cause fascial hypertrophy. Following opera-



FIG. 1. Dupuytren's contracture, grade 1, of the left hand.

tion I occasionally have noted an acute swelling with local redness and heat and rarely an attack of arthritis, without evidence of wound infection or drainage. I have seen this condition complicating arthritis in many cases and believe repeated trauma may be a possible exciting factor in the causation of the contracture. I feel that the avoidance of trauma to affected regions is of great importance. The removal of foci of infection and the improvement of the general health may also be factors in the prevention of the development of the disease and are well worth while.

In some cases in which the deformity is not great, subcutaneous fasciotomy may relieve the contracture if great care is exercised in order to avoid injuring blood vessels, nerves and tendons. However, treatment of Dupuytren's contracture is most successful if the contracted palmar fascia is removed and proper postoperative measures are applied. In order to remove

the fascia it is necessary to make an incision which will permit adequate exposure. The longitudinal incision over the

because it is densely adherent to the hypertrophied fascia; in such instances the involved skin and fascia are excised, and a

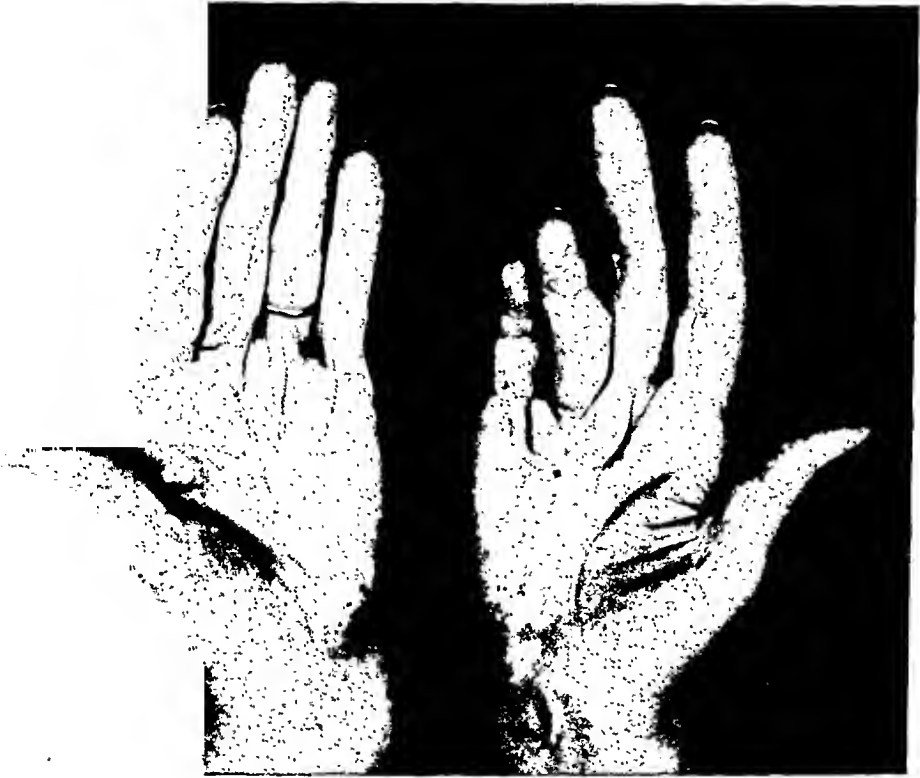


FIG. 2. Dupuytren's contracture, grade 2 of the right hand and grade 1 of the left hand.

fourth metacarpal bone has been used most commonly in the past, but because of the difficulties of exposure and the tendency to irritation from repeated movement this method has been superseded by incisions made along the fifth metacarpal bone and transversely along the linea mensalis. Because the linea mensalis is formed as the result of flexion of the little, ring and middle fingers and because the palmar fascia divides just distal to it and forms bands which pass to the fingers, incision at this point affords excellent exposure. Furthermore, the majority of contractures form in this region at the base of the ring finger, and unless the fingers are involved by extension of the contracture it is seldom necessary to make a second incision in the palm. An anterolateral incision is used in dissecting the fascia of the fingers.

For some of the extensive lesions it is obvious that the skin must be sacrificed,

skin graft of full thickness is applied to cover the defect. For many years I have used the cuff of the sphygmomanometer to obtain a bloodless field, releasing it occasionally to permit circulation and to facilitate isolation and ligation of the small bleeding points with very fine catgut. It is highly important that the wound be dry and that the clots be removed before the wound is closed.

Strong antiseptic substances should not be placed in the wound. If any solution is to be used, I prefer an isotonic solution of sodium chloride. Great care must be taken in handling the tissues; fine hemostats and forceps, retractors with blunt edges and moist sponges are preferable.

I usually expose the narrow, upper end of the palmar fascia, isolate it with small, blunt-pointed dissecting scissors, pass a hemostat under it and, after clamping it firmly, divide it with a knife. The fascia

can then be raised by gently pulling the forceps away from the palm, and with a fine knife or scissors the fasciculi can be divided as they pass in various directions. The dissection is continued distally until all contracted fascia has been freed; if such fascia should continue into the fingers, separate incisions and dissections should be made. At the time that the contracted fascia is removed from the fingers, great care must be taken in separating the nerves and blood vessels from the fibrous mass in which they lie. Should the surgeon merely expose the fibrous mass and excise it, he may find later that the patient has resultant anesthesia and impaired circulation. I have mentioned the possibility of the use of subcutaneous operations if the involvement is slight. However, it is difficult for me to understand how the fascia, when extensively involved, can be safely and satisfactorily sectioned subcutaneously, in view of the fact that even with good hemostasis and adequate exposure the operation obviously is difficult.

The strictest aseptic technique must be employed, as infection in an extensive wound of the palm would be disastrous. Preliminary preparation by washing the hand thoroughly with soap and water and applying an alcohol dressing the night before operation is excellent, but it has not always been carried out unless the appearance of the extremity has indicated that it is necessary. As a rule, I scrub the hand with benzine to remove the oil from the skin, then apply ether to dry the skin, and a coat of tincture of merthiolate or tincture of iodine diluted one-half with alcohol. Use of this method has been attended with marked success, and patients who have undergone this preparation have not had infections.

The wound is closed snugly without drainage. A posterior splint of aluminum is applied to hold the involved fingers in extension. The splint should be well padded with gauze to protect the skin over the articulations from excessive pressure. If there is difficulty in obtaining full exten-

sion of the fingers, it is best to allow them to remain flexed slightly and to straighten them gradually. This is accomplished by



FIG. 3. Dupuytren's contracture of the right hand, grade 2.

placing an adhesive band about the tip of the finger and pulling it toward the splint. The splint extends upward to about the middle of the forearm and is moulded to fit the contour of the arm. Dressings are not changed for a week. When they are changed, the gauze, if dry and adherent, is allowed to remain in position; the fingers are inspected for signs of pressure and the splint is reapplied. The duration of fixation varies with the extent of the deformity; I prefer to allow the incision to heal and then begin motion, reapplying the splint for the night until free motion is obtained. When the contraction recurs, it usually is in those cases in which operation has been performed with apparent success but fixation has either not been applied or has been continued for an insufficient time.

In dealing with some extensive lesions, especially if operations have been performed previously and ankylosis has followed, I have excised the involved fascia and skin, and have used the skin from a disarticulated, functionless finger as a pedicle graft to cover the denuded palm;

the results have been excellent. This method usually has been used in those cases in which it has been necessary to

applied to the palmar surface of the hand and fingers for thirty minutes daily. Following the application of heat, passive

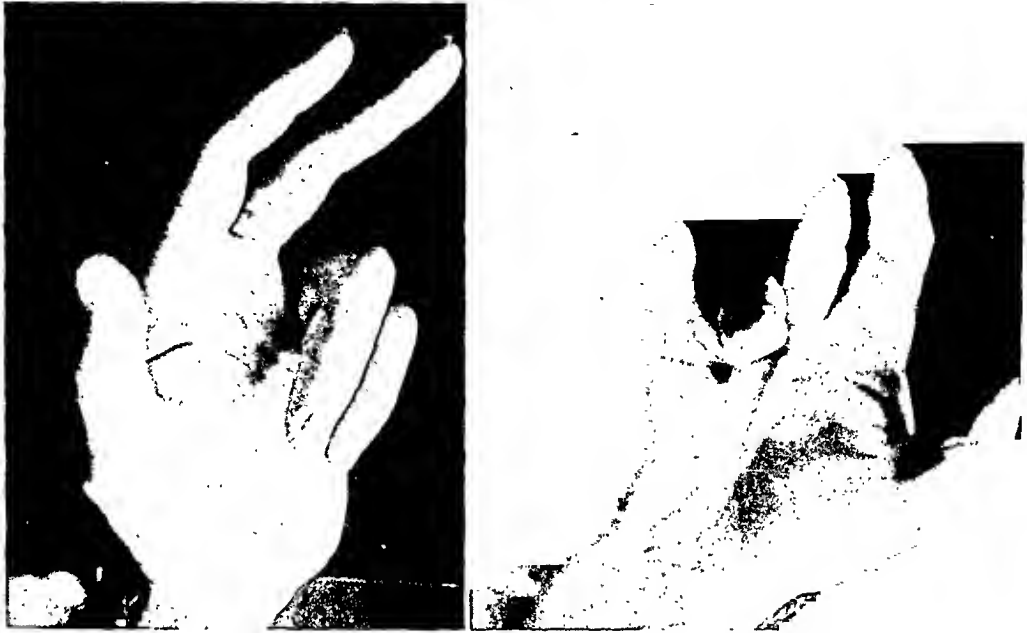


FIG. 4. Bilateral Dupuytren's contracture, grade 3.

remedy a poor result of a former operation; the finger has been acutely flexed and prognosis for function of the finger is poor. Operation produces a more speedy and satisfactory result than could be obtained by more conservative methods, but, of course, it has a limited field.

The postoperative treatment which I commonly employ is as follows: The primary dressing is left in place for a week to ten days, during which time firm clotting and drying of the wound take place. A dorsal splint is worn during this time and movement is avoided. The stitches may then be removed; the heavy fibrotic scabs which form on either side of the skin incision should not be removed, as it is best to allow them to become loose. If this is not done the wound may open and further complications may arise. During this postoperative period, which usually lasts for about seven days, radiant heat (from a u-shaped, six-lamp baker, containing 60 watt bulbs; or from a 250 watt gas-filled tungsten bulb in a cup-shaped reflector, at a distance of 2 feet, 61 cm.) is

movements of the fingers are instituted for five minutes; one should take great care to see that the movements are sufficiently gentle to avoid opening the skin wound. Early motion is urged, but not at the expense of creating drainage, as this may cause infection.

The hand and forearm may now be introduced into a whirlpool bath, since the skin incision should by this time be well healed. The whirlpool bath is an oval tub containing whirling, aerated water which is kept at a temperature of 110°F. It produces marked hyperemia of the superficial tissues and, because of its gentle massage effect, there is relaxation of the musculature and a sedative effect on the endings of the peripheral nerves. The whirlpool bath is applied for thirty minutes, and it ideally prepares the part for massage and manipulation. Again, the firm scabs around the wound are undisturbed until they fall off of their own accord. At this stage, active assistive exercises may be instituted. The patient makes an active effort to move the affected



fingers, and he is assisted in the completion of these movements by the operator. A period of five minutes is usually devoted to

deformity encountered in Dupuytren's contracture. In a previous report<sup>22</sup> I have given the method of grading the degree of



FIG. 5. Bilateral Dupuytren's contracture, grade 4.

this type of exercise. As treatment continues, the assistive movements of the operator are decreased, and active movements are increased until the patient is able to use the fingers actively in a normal manner. During this time, dressing of the wound is continued until the scabs have fallen off and complete healing has been established. The continuous dorsal splint, however, is removed, and if a tendency to flexion deformity still persists, an aluminum hand splint is applied at night. This night splint is usually worn by the patient for one month. At the end of the fourth week, the patient is provided with a baker or heat lamp of the type described and is instructed in its home use. At this time all danger of injury to the dissected nerves, mentioned by Davis, has disappeared, and the patient is shown how to apply the gentle kneading and friction of the palm; he also is specifically instructed in extension and flexion exercises of the fingers, and is further warned to avoid repeated deep trauma to the palm of the hand.

#### REPORT OF CASES

The following case histories and illustrations bring out some of the alleged etiologic factors and illustrate various degrees of

deformity encountered in Dupuytren's contracture.

**CASE I.** A boy, aged 17 years, had been in an automobile accident thirteen months before he came to the clinic. He had sustained an injury to the upper part of the thorax, which had caused traumatic myelitis and immediate temporary paralysis of the arms and legs. There had not been any evidence of a fracture. A few days after the accident he had been able to move his arms and legs slightly, but he never had regained full use of his hands. Dupuytren's contracture had been noticed about one month after the injury.

The patient was operated on and a typical contracted fascia excised from the left hand. (Fig. 1.) The pathologist made a diagnosis of chronic inflammatory tissue with marked fibrosis. The convalescence was satisfactory. After he left the clinic he reported that his condition had improved but that he still had a little residual paralysis.

**CASE II.** A woman, aged 58 years, had noticed a gradual tightening of the flexor tendon of the fourth and fifth fingers of the right hand for five years before she came to the clinic. (Fig. 2.) This had been followed by a similar contracture of the left hand.

Examination disclosed a typical Dupuytren's contracture. The fourth and fifth fingers of the right hand were chiefly involved. Operation was performed on both hands and the



contracted, thickened fascia was excised. The pathologist reported chronic inflammatory tissue and fibrosis (Dupuytren's contracture).

CASE III. A priest, aged 52 years, came to the clinic because of disability of his hands; he also requested an examination for diabetes. Three years prior to his admission a diagnosis of diabetes had been made and treatment had been instituted. He also complained of pain and stiffness in his knees. The first symptoms in his hands had been redness of the right palm, which he had noticed about one year previous to his admission. There had not been any injury or previous infection. Gradual contracture of the palms and fingers of both hands had occurred; the deformity of the right was more marked than that of the left. He had noticed the formation of firm, round, fixed nodules, which were tender. A physician consulted regarding this condition had made a diagnosis of Dupuytren's contracture and advised treatment. (Fig. 3.)

Examination revealed that the concentration of sugar in the urine was 3.2 per cent. The tonsils were infected and the diagnosis of Dupuytren's contracture was confirmed. No operation was performed but he was treated for the diabetes.

CASE IV. A lumberman, aged 63 years, came to the clinic complaining of a flexion deformity and disability of both hands. He had noticed a contracture of the third and fourth fingers of the right hand and of the fourth and fifth fingers of the left hand for six years before he had come to the clinic. He believed that the handling of lumber and the resulting irritation may have been a factor in the production of his condition. (Fig. 4.)

Examination disclosed definite infection of the tonsils and ringworm of the left hand. Multiple tenotomies were performed on the palmar fascia of the right hand; dissection and removal of a portion of the fascia over the proximal phalanx were carried out.

The patient had symptoms of arthritis of the knees before the operation and following it there was some stiffness in the hand; he was referred for physical therapy and for removal of the infected tonsils. Two months later the surgeon noticed that arthritis was developing in the small joints of the hand; treatment was carried out and the patient improved gradually. He was advised to continue the physical therapy at home. Improvement continued.

The pathologist reported pus in the tonsils, which had been removed. This patient also had undergone an operation for an ulcer of the duodenum.

CASE V. A merchant, aged 65 years, came to the clinic because of a flexion contracture of both hands. He first had noticed dimpling in the fifth finger of the right hand about eight years before he came to the clinic. This had resulted in marked contracture of the fifth finger, which defied all methods of conservative treatment. (Fig. 5.)

Examination revealed that the fifth finger on each hand was acutely flexed and almost touching the palm. The contracted palmar fascia extended well across the palm. An operation was performed on the left hand and the contracted palmar fascia was excised. This permitted full extension of the finger. Posterior splints were applied and physical therapy was carried out. The pathologist reported chronic inflammatory tissue and fibrosis (Dupuytren's contracture). The patient left the hospital two days following the operation and insisted on returning home after four more days. He was advised to continue with the splints and return in three weeks. His convalescence was uneventful.

#### SUMMARY

It is evident from a review of the literature that conservative treatment, namely, stretching, heat and massage and the use of ointments and irradiation, has failed to prevent or cure Dupuytren's contracture. Following an experience of more than twenty years, during which time I have seen 315 patients who were afflicted with this condition and have operated on more than 100 of them, I have come to the conclusion that the operation of choice is surgical excision of the involved palmar fascia. The result has been satisfactory in about 90 per cent of the cases. Subcutaneous section of the constricting bands of palmar fascia is a satisfactory method of treating certain patients. A carefully managed program of physical therapy is necessary. A combination of excision, splinting and physical therapy results in a useful functioning extremity.

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# THE PROBLEM OF ACUTE APPENDICITIS

## A SURVEY COVERING FOUR YEARS

H. JACKSON KING, M.D.

Associate Attending Surgeon, Binghamton City and Lourdes Hospitals

BINGHAMTON, NEW YORK

THIS paper presents a series of cases of appendicitis at the Binghamton City Hospital during the years 1934-1937 inclusive and, for the purpose of comparison, during the year 1929-1930. Comparable months are included in each year, that is, from September of one year to September of the next. Cases in which the appendix was removed routinely or in which appendicitis did not appear to be the principal pathology are not included. Cases of chronic appendicitis and so-called subacute appendicitis are grouped under one classification "chronic appendicitis." They are not important in this analysis except for their number and chance mortality.

During these four years, 1,628 patients were operated on primarily for appendicitis. There were forty-four deaths, giving a mortality of 2.7 per cent for the series. There were 824 chronic cases and 804 acute cases. Among the 824 chronic cases there were three deaths, a mortality for that group of .36 per cent.

TABLE I

	Operated	Died	Mortality Per Cent
Acute uncomplicated.....	584	2	.34
Acute local peritonitis.....	132	10	7.57
Acute with abscess.....	56	8	14.28
Acute diffuse peritonitis.....	32	21	65.62
Total.....	804	41	5.09

The 804 cases of acute appendicitis were selected after careful personal study of the histories and physical examinations,

the temperature and pulse charts, laboratory data, operative sheets and pathologic diagnosis. Only those cases were considered acute in which the diagnosis was certain beyond any reasonable doubt. Mortality statistics for the group are indicated in Tables I and II.

TABLE II

	Operated	Died	Mortality Per Cent
1929-1930.....	176	11	6.2
1934-1935.....	188	8	4.2
1935-1936.....	214	9	4.2
1936-1937.....	226	13	5.7
Total.....	804	41	5.09

*Age Incidence and Mortality.* Acute appendicitis is primarily a disease of youth and young adulthood. In Krech's series 56 per cent of all the cases occurred during the second and third decades of life. In the present series 60 per cent of the cases occurred during the same two decades. It is not from this particular age group, however, that appendicitis takes

TABLE III  
AGE INCIDENCE AND MORTALITY—ALL CASES

Years	Total	Died	Mortality Per Cent
1-10.....	184	8	4.34
11-20.....	641	6	.93
21-30.....	447	6	1.34
31-40.....	189	3	1.6
41-50.....	82	6	7.3
51-60.....	44	6	13.6
Over 60.....	41	9	21.95
Total.....	1628	44	2.7

its heaviest toll of life. Appendicitis proves most dangerous to the person beyond the age of 40 years. (Tables III and IV.) The mortality peak in the series

TABLE IV  
AGE INCIDENCE AND MORTALITY—ALL CASES

Years	Total	Died	Mortality Per Cent
1-10.....	105	8	7.6
11-20.....	302	6	1.98
21-30.....	184	5	2.7
31-40.....	96	3	3.1
41-50.....	45	4	8.88
51-60.....	37	6	16.2
Over 60.....	35	9	25.7
Total.....	804	41	5.09

occurred in the group over 60 years where in thirty-five cases there were nine deaths, a mortality of 25.7 per cent. The youngest patient in this series was 2½ years old and the oldest 80 years.

TABLE V  
SEX INCIDENCE AND MORTALITY ACUTE

	Number	Died	Mortality
Males.....	429	28	6.5
Females.....	375	13	3.5

*Sex Incidence and Mortality.* Most appendicitis series report a majority of males over females. Krech's survey in New York City showed a proportion of sixty-eight males to thirty-two females. The males in this series outnumbered the females in the proportion of fifty-three to forty-seven.

More important than the sex morbidity, however, is the sex mortality. The mortality for the entire male series was 6.5 per cent, as compared to a mortality of 3.5 per cent among the females. This difference of 3 per cent in mortality actually represents a 46 per cent greater mortality for males than for females. The factors underlying this sex variation in mortality are not clearly understood.

It seems that they must bear a relationship to the singular ability of the female peritoneum to localize peritonitis of lower abdominal origin.

SEASONAL INCIDENCE

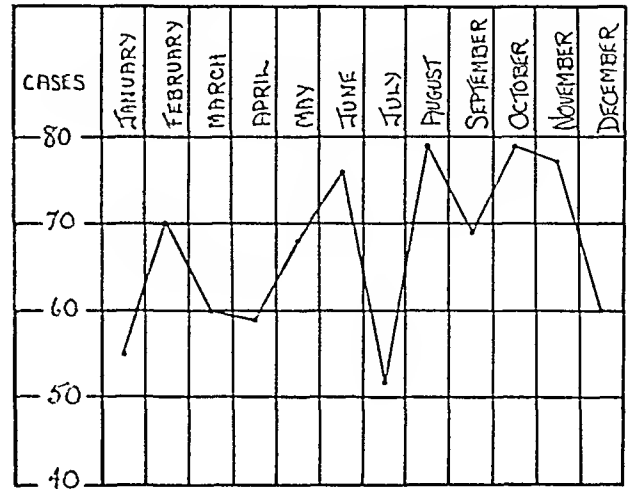


CHART 1.

*Seasonal Variation.* There appears to be considerable variation in the seasonal incidence of acute appendicitis. The graph representing case incidence according to months in this series was fairly evenly sustained during most of the months of the year, but showed a sharp decline for the months of July and January. It is doubtful whether the ingestion of fruit during the late summer months has the importance in the causation of this condition that has been attributed to it in the past.

*Use of Cathartics.* Bower has thoroughly studied the importance of cathartics in acute appendicitis. It was very impressive to him that only one in sixty-four of the appendicitis patients who had not received a laxative died. On the other hand, of those who received one laxative, one in eighteen died, and of those who received two or more laxatives, one in eleven died. Moreover, in cases of spreading peritonitis, if a laxative had been administered the patient had only one chance in seven of getting better.

Interesting data were obtained from the cases complicated by peritonitis during the final three years of the series, that is, from 1934 through 1937. There were 160

cases of acute appendicitis with peritonitis. Ninety of these case histories contained no record of the use of cathartics or enemas prior to admission while seventy histories contained definite mention of one or both. In sixty-four cases the history was positive regarding cathartics and enemas. In only six was it negative. Thus in 40 per cent of the cases which developed peritonitis cathartics or enemas had been given.

The thirty deaths which occurred during the same three years were likewise studied in order to determine whether cathartics or enemas had been given in those cases. The histories of sixteen of these cases contained no mention of the subject of cathartics or enemas. Among the remaining fourteen deaths, however, not one history failed to record the use of a cathartic or an enema.

Although many of the histories in the series failed to mention whether cathartics or enemas had been used in treatment, nevertheless interesting data were obtained where definite mention of the subject was made. One hundred ninety-one histories contained definite mention regarding the use of cathartics or enemas. This was positive in 147 cases. Among this group there were twelve deaths, or roughly one death in twelve cases. On the other hand, forty-four histories stated definitely that cathartics or enemas had not been used, and among those forty-four there was not a single death. Also, among 437 cases in which there was no definite record concerning the use of cathartics there were eighteen deaths, or one death for each twenty-four cases.

*Type of Incision and Drainage.* Data were obtained from the last three years of the series chiefly because many of the operative records contained no definite mention of the type of incision used. There were 164 cases in which the right rectus incision was used. This group had eight deaths, a mortality of 4.9 per cent. There were 140 cases in which the McBurney incision was used. This group had six

deaths, for a slightly improved mortality of 4.3 per cent. In addition, 324 cases with no definite record of the incision used showed sixteen deaths, or a mortality of 4.9 per cent.

Regarding the matter of drainage the records showed a definite trend toward less frequent drainage in acute appendicitis.

Almost without exception, however, drainage was used in peritonitis cases. In three cases of localized peritonitis, not drained, drainage occurred through the incision. Also one patient with localized peritonitis which was not drained healed uneventfully. Cecal drainage was used in two cases of appendiceal abscess, with recovery in both cases.

In the year 1929-1930 drainage was employed in eighty-one of 176 acute cases (46 per cent). In 1934-1935 the incidence was lowered to seventy-three of 188 cases (38.8 per cent). In 1935-1936 it was further cut to sixty-five of 214 cases (30.3 per cent), and in 1936-1937 to fifty-eight of 226 cases (25.6 per cent). Thus in a period of seven years the incidence of drainage in acute appendicitis was reduced by 20.4 per cent, which represents an actual decrease of 44 per cent in its use.

In all, 277 cases were drained. Of these 216 were cases of peritonitis (only four peritonitis cases in the series were not drained) while sixty-one drained cases were uncomplicated by peritonitis at the time of operation. Analysis of the latter group reveals that in the year 1929-1930, twenty-two of 116 uncomplicated cases were drained; in 1934-1935, twenty-one of 132 were drained; in 1935-1936, fifteen of 164; and in 1936-1937 only eight of 172. Thus the incidence of drainage in uncomplicated cases was 19 per cent the first year, 16 per cent the second year, 9 per cent the third year and 4.6 per cent in the year 1936-1937. The incidence of drainage among uncomplicated cases therefore has been reduced a total of 14.4 per cent which represents an actual decrease of 75 per cent in that procedure.

**Time Element.** Bower emphasized the importance of two factors in the mortality of acute appendicitis: (1) the use of

cases of forty-eight to seventy-two hours' duration the mortality was 17 per cent; in twenty-six cases of four days' duration,

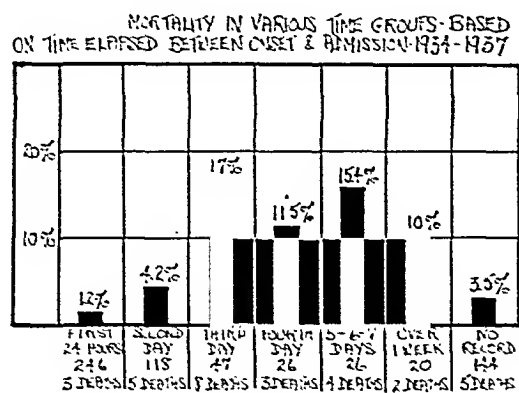


CHART II.

laxatives in abdominal pain; (2) delay in hospitalization. He found that the mortality rate of cases admitted to the hospitals forty-eight to seventy-two hours after the onset of the attack was practically three times that of cases admitted within twenty-four hours. Where seventy-two hours or more had elapsed the death rate was four times that of the twenty-four-hour group.

It is generally agreed that the mortality rate for patients operated on within the first twenty-four hours of the disease is very low. It should not exceed 1 to 1.5 per cent. There is usually a moderate though definite increase in the rate during the second twenty-four hours. A marked increase in mortality occurs in the forty-eight to seventy-two-hour group. Following this there may be a gradual subsidence in mortality until, in the group showing symptoms for more than a week, the mortality may still be eight or ten times what it was for the first twenty-four hours of the disease. The cause of the frightful mortality increase which begins on the third day is of course the complication of peritonitis.

Of 246 patients admitted with histories up to twenty-four hours in duration, three died, a mortality of 1.2 per cent. Among 118 cases with histories of twenty-four to forty-eight hours' duration the mortality was 4.2 per cent. In forty-seven

COMPARATIVE MORTALITY ACCORDING TO PATHOLOGICAL TYPES

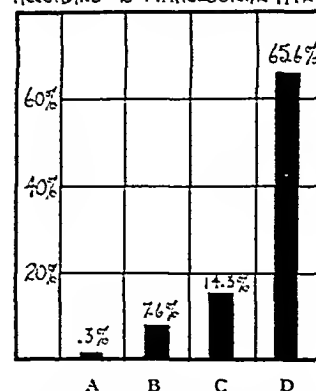


CHART III. A, acute appendicitis, uncomplicated. B, local peritonitis. C, acute appendicitis with abscess. D, diffuse peritonitis.

11.5 per cent; in twenty-six cases of five, six and seven days' duration, 15.3 per cent; and in twenty cases of over one week's duration, 10 per cent.

The forty-seven cases in the group with histories of forty-eight to seventy-two hours' duration showed eight deaths. This group, which comprised only 9.7 per cent of the series, accounted for 32 per cent of the deaths. The mortality for the group having histories under forty-eight hours' duration was 2.2 per cent and for the group with histories over forty-eight hours, 14.3 per cent.

**Comparison of the Four Years.** The mortality rate for acute appendicitis in 1929-1930 was 6.2 per cent. In 1934-1935, five years later, it was 4.2 per cent. In 1935-1936 it was the same, but in the following year rose to 5.7 per cent. What appeared to be a definite improvement in mortality during the middle two years of the series was lost in the last year's increased mortality. The reason lay in the unfortunate management of several difficult cases which accounted in all for thirteen deaths among 226 cases.

Among the uncomplicated acute cases there was one death in 116 cases (1929-1930); no death in 132 cases (1934-1935);

one death in 164 cases (1935-1936); and no death in 172 cases (1936-1937). The highest mortality for a single year was

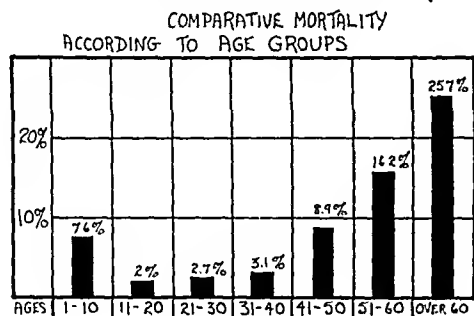


CHART IV.

under 1 per cent and the mortality for the total of 584 cases was only .34 per cent.

The cases complicated by local peritonitis showed a mortality of 6 per cent in 1929-1930; 8.8 per cent in 1934-1935; 3.6 per cent in 1935-1936; and the very high mortality of 10.8 per cent in 1936-1937. The four-year average for 132 cases was 7.57 per cent which is a fairly satisfactory figure for local peritonitis.

Appendicitis with local abscess showed a mortality rate of 6.2 per cent in 1929-1930; 18.7 per cent in 1934-1935; 7.1 per cent in 1935-1936; and 30 per cent in 1936-1937. The four-year average for fifty-six cases was 14.3 per cent, a mortality which is much too high for this type of case.

The cases complicated by diffuse peritonitis had appalling mortalities. In 1929-1930 the mortality in this group was 63.6 per cent, in 1934-1935 it was 33.3 per cent; in 1935-1936 75 per cent; and in 1936-1937 85.7 per cent. The four-year average for thirty-two cases was 65.6 per cent, or roughly two deaths out of three cases.

#### DISCUSSIONS OF DEATHS

In 1929-1930 there were eleven deaths in the series of 176 acute cases. Five of the deaths in this group occurred in patients who on admission showed unmistakable signs of a very severe infection, profound toxemia, rapid pulse, and varying degrees of abdominal distention. All five

died within forty-eight hours of operation. It seems fair to question whether it might not have been better in these cases to delay operation for perhaps twenty-four to forty-eight hours, with the hope that rest, fluids, and supportive measures (after the method of Ochsner) might be of help in localizing their peritonitis so that abdominal drainage might be performed more safely and with a better chance of recovery. Three in this group were 10 years of age or under, when the peritoneum and omentum are notoriously slow to localize spreading abdominal infection. Setting aside those three debatable cases, there are left two others which it appears were ideally suited for delayed treatment. One presented an overwhelming diffuse peritonitis, the other a questionable local, but probably highly toxic spreading peritonitis.

In the 1934-1935 series of 188 cases there were eight deaths, two of which we have classified as catastrophes. Of the remaining six, two occurred in hemolytic streptococcus peritonitis. There was one case of appendiceal abscess of seven days' duration in a 52 year old male, who died of general peritonitis ten days after drainage of the abscess.

Three cases are left, having histories of forty-eight to seventy-two hours' duration. All died of general peritonitis following operation. Two of these were probably better suited to delayed than radical treatment; one was a 46 year old female whose pulse on admission was 120, who was very toxic and showed signs of spreading peritonitis. She was operated on soon after admission, and died of general peritonitis five days later. The other, a 58 year old female, with a three day abdominal complaint, showed a profound toxemia on admission, and a pulse of 140, which was weak and thready. She was also operated on shortly after admission and died twenty-four hours later.

In the 1935-1936 series of 214 acute cases there were nine deaths. One death occurred in a male of 60 years who had an

uncomplicated appendicitis. A 71 year old female with an appendiceal abscess of unknown duration died on the sixth postoperative day of generalized peritonitis. A 17 year old boy who had a localized retrocecal peritonitis died fifty-three hours after operation of generalized peritonitis. A 73 year old male with a three-day history of illness and a generalized peritonitis at operation, showed good progress until the twelfth postoperative day when he developed lobar pneumonia. Three children under 10 years of age were admitted with general peritonitis. There were two cases with generalized peritonitis on admission which were probably better suited to delayed treatment: one, a 69 year old male with an abdominal history of forty-eight to seventy-two hours, was very toxic on admission and died fifty-five hours postoperatively; the other, a 31 year old male with a history of twenty hours' duration and showing signs of a very fulminating peritonitis, died thirteen and one-half hours after operation.

In the 1936-1937 series of 226 acute cases there were thirteen deaths, one a catastrophe and two due to pneumonia.

A 54 year old male having a history of nine days' duration and a localized abscess at operation died of generalized peritonitis on his seventh postoperative day.

A 51 year old male with a seven-day history and a retrocecal abscess died on his fifth postoperative day of a very extensive local necrosis and toxemia.

A 62 year old male having a thirty-six-hour history of illness and a localized process at operation developed general peritonitis and died on his nineteenth postoperative day. A 5 year old male having a four-day history and a localized peritonitis (which was not drained, but which later broke down) developed a generalized peritonitis and died on his tenth postoperative day.

There were four deaths in cases having general peritonitis on admission. Two patients were admitted with fulminating

and highly toxic spreading peritonitis, who would probably have been better suited to delayed treatment. One was a 14 year old male having a twenty-four-hour history and who had had active catharsis. He died five days after operation of a generalized peritonitis. The other was an 11 year old male having a history of two days' duration who died thirteen hours postoperatively.

In résumé, there were forty-one deaths, of which four were catastrophes. These comprised two cases of cerebral accident, one of ether convulsions, and one of rupture of the wound with evisceration of the bowel. Of the remaining thirty-seven deaths, three resulted from postoperative pneumonias, three from general peritonitis of extremely virulent hemolytic streptococcal origin, and one from sepsis and toxemia caused by a most extensive local retrocecal and wound necrosis. The remaining thirty patients died of generalized peritonitis. That surgical shock played a part in some of the deaths which occurred within forty-eight hours of operation is doubtless true. The thirty deaths may again be subdivided into one acute uncomplicated case in which generalized peritonitis developed, four cases of apparently localized peritonitis which became generalized after operation, four cases of localized abscess in which the peritonitis became generalized after drainage of the abscess, and twenty-one cases of generalized peritonitis in which infection continued to be generalized until death.

In terms of percentages the causes of death are: generalized peritonitis 80.5 per cent; localized peritonitis 2.4 per cent; other causes (pneumonia, catastrophes, etc.) 17.1 per cent. A recent figure from Bower's series gives generalized peritonitis as the cause of death in 81 per cent of his cases.

It appears that there were at least eight cases which would probably have been better treated by the Ochsner régime. From the history and physical findings of a fulminating and rapidly spreading



peritonitis, as well as from the rapidity with which they died following surgery, these might very conceivably have had a better chance of surviving had a régime of rest, morphine and parenteral fluids been instituted until such a time as their peritoneal infection had become localized, or their general bodily resistance sufficiently raised to withstand operation. From this number are excluded those controversial cases from either extreme of life in which conservative practices are considered less rational since the peritoneum handles spreading infection poorly in the very young and old age groups.

#### THE TREATMENT OF ACUTE PERITONITIS

This series shows that among 220 cases complicated by peritonitis there were thirty-nine deaths. Any surgical disease whose operative mortality is 17.7 per cent certainly is worthy of careful consideration.

Catharsis is a factor which has a profound effect upon mortality in peritonitis cases. Bower has recently shown that the laxative-induced spreading peritonitis is a distinct entity, more virulent and more fatal than the operative-induced type. Of considerable importance is the technique of the operative procedure. The McBurney incision or one of its modifications is employed, and a simple, quick manipulation performed within the peritoneal cavity. Appendectomy should be carried out if the organ is easily accessible, otherwise simple drainage of the abdominal cavity.

Utmost care and judgment in maintaining proper fluid and electrolyte balance is the key to good postoperative management. Some favor bacterial lysates, gas antitoxin and whole blood as adjuvants in treatment.

The question of the advisability either of immediate operation or of temporary delay enters into the management of every case, complicated by peritonitis. *The weight of surgical opinion favors operation and removal of the early ruptured appendix*

*provided that removal does not necessitate the breaking down of a localizing process.* It is not good surgery to try to treat peritonitis by the clock, but in a general way it might be stated that the Ochsner treatment should be reserved for cases of ruptured appendicitis in which the process has existed for at least thirty-six to forty-eight hours, and in which definite signs of a very virulent and spreading infection are present, as evidenced by intoxication, rapid pulse and abdominal distention.

There is perhaps too great a tendency on the part of surgeons to make the treatment of appendiceal abscess an emergency. General peritoneal contamination following a premature drainage is the chief danger. This can be obviated in some cases by extraperitoneal drainage, or by packing with gauze either to the region of the abscess, or to the parietal peritoneum and waiting for adhesions to form before opening into the abscess. Serious consideration of the subject of appendiceal abscess is justifiable when we realize that in this series fifty-six cases of local abscess showed eight deaths for a mortality of 14.28 per cent. This mortality is high indeed for a condition which nature herself could probably treat with better success if left strictly to her own resources.

*Bacteriophage.* In a previous paper, the literature on the subject of bacteriophage in the treatment of peritonitis was reviewed and our results with a phage called cololysate (Lilly) were reported. The conclusions reached at that time were that in a small though representative series of complicated cases a definite reduction in mortality occurred among the cases treated with bacteriophage.

At the present time more complete figures are available covering the results with bacteriophage in a somewhat larger series. Bacteriophage was used, during the last three years of the foregoing series, in a total of nineteen cases. There were nine cases of local peritonitis with no death; 4 cases of localized abscess with no

death; and six cases of diffuse peritonitis with three deaths. The mortality for the entire group was 15.8 per cent. A parallel control group of 160 cases of peritonitis in which bacteriophage was not used showed a mortality of 18.1 per cent. This difference in mortality of 2.3 per cent in favor of the bacteriophage group represents an actual difference of 12.7 per cent in the mortality rate. Moreover it is only fair to state that in the control series the proportion of general peritonitis (which showed by far the highest mortality) to local peritonitis is 1:7.5, in the bacteriophage series it was 1:1.5.

Although they do not properly belong among the foregoing series, nine additional cases of peritonitis from ruptured appendix have been treated with bacteriophage since the conclusion of the present series. They comprise five cases of local peritonitis with no death; two cases of local abscess with no death; and two cases of general peritonitis with one death. Combining the data of these two groups we arrive at a total of twenty-eight cases of peritonitis treated with bacteriophage, having four deaths, a mortality rate of 14.3 per cent. The ratio of general to local peritonitis is 1:1.75 as compared to the ratio of 1:3.5 in the general series.

This final mortality rate of 14.3 per cent compares very favorably with that of 18.1 per cent for the control series mentioned above; as well as with the mortality rate of 17.7 per cent for the entire complicated group in the foregoing series. A more general use of this agent should provide in time a larger series of cases, which will permit of a more scientific evaluation of its worth.

#### CONCLUSION

Certain conclusions may be drawn from this mass of information.

1. Despite the fact that statistics of appendicitis mortality which are available from broad surveys by insurance companies

and from the United States Bureau of Census, reveal that there has been a very definite downward trend in that mortality in the course of the past ten years, the results of this series fail to show that a comparable improvement has taken place at this hospital. This is true despite the fact that the incidence of early, and therefore, more favorable cases has been steadily increasing.

2. The mortality rate among the cases complicated by peritonitis has failed to improve.

3. Acute uncomplicated appendicitis has shown a mortality rate of .34 per cent for a period of four years—a figure which is not only extremely creditable, but probably almost irreducible.

4. Appendiceal abscess has a mortality rate of 14.3 per cent which is entirely too high.

5. A short but representative experience with bacteriophage in the treatment of ruptured appendicitis indicates that it may be a valuable adjunct in the treatment of these difficult cases.

6. Improvement in appendicitis mortality which is, in effect, improvement in peritonitis mortality calls for a revision of our present methods of treatment and the introduction of such new features as have been tried and proved superior.

7. The key to a lowering of the mortality from appendicitis lies in reducing the incidence of peritonitis.

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# CASE REPORTS

## FASCIAL PLASTIC OPERATION FOR THE RESTORATION OF THE ULNAR COLLATERAL LIGAMENT OF THE ELBOW IN MARKED LATERAL INSTABILITY OF THE JOINT AFTER ITS RESECTION\*

MICHAEL S. BURMAN, M.D.

NEW YORK CITY

THE principle of reinforcing lax ligaments or creating new ligaments by fascial strips is well known. The operative correction of severe lateral instability of the elbow joint is an uncommon experience in the reconstructive surgery of this joint.

### CASE REPORT

The patient, a colored woman of 38 years, received a charge of buckshot in the left elbow in 1922. She was operated on at once and a plaster of Paris cast applied for four weeks. Infection followed and two other operations were done for the relief of the infection, the last one in 1924. The exact nature of these operations is not known but it is known that a resection of the elbow was done at one of these operative periods by a study of the roentgenograms of the elbow.

The patient is a laundress. She has always favored the left elbow because of its instability and its lack of strength. She has been unable to carry heavy weights with the left hand. She, herself, noted that the left forearm would swing away from the side of the body when she did so. There was usually no pain in the elbow. The fourth and fifth fingers of the left hand were numb at times.

She entered the clinic because of the disability of the left elbow and also because of severe pain which had recently developed on the inner side of the right elbow.

There was tenderness over the internal epicondyle of the right elbow due to an epicondylitis of the right elbow as a consequence of strain overuse of the joint.

The major disability of the left elbow was its abnormal valgus of about 50 degrees. This defect in lateral stability was brought out best on passive abduction of the extended forearm, the arm being steadied. The right forearm could be brought into a valgus position of about 10 to 15 degrees when this same maneuver was carried out. As the left forearm was carried into valgus, an abnormal clicking was felt and heard on the inner side of the elbow joint, as if subluxation of one bone on another were taking place. This occurred particularly in the first 20 degrees of valgus. If valgus position was passively increased beyond this point, the patient had severe pain on the inner side of the elbow due to the abnormal stretching of the ulnar nerve. The abnormal position in valgus of the forearm took place only in supination and extension of the forearm. She rarely allowed the valgus position of the elbow joint to exceed 25 degrees actively. Extension of the elbow was weak and limited to 140 degrees by action of gravity and the weak contraction of the atrophic triceps muscle. Flexion was weak and did not surpass 25 degrees from the position of extension. Both pronation and supination were limited. This movement in rotation did not take place in the upper radio-ulnar joint since this joint had been destroyed, but rather in the elbow joint itself. There was no cubitus varus deformity and the extended forearm could only be brought to the neutral position. The bony configuration of the elbow joint was abnormal. The humerus was displaced posteriorly at its distal end and formed a rounded posterior bony eminence which simulated an olecranon process. The olecranon itself was absent.

\* From the Hospital for Joint Diseases, Service of Dr. Leo Mayer.

There were two longitudinal scars anteriorly and one posteriorly, all placed so that the joint was at their center.

An incomplete ulnar nerve palsy was present. Sensation was usually normal in the fourth and fifth fingers but sometimes hyperesthetic. The intrinsic muscles supplied by the ulnar nerve were paralyzed. There was complete paralysis of the adductor muscles of the thumb, including the first dorsal interosseous muscle. Adduction of the thumb was accomplished by the action of the long extensor of the thumb. The fourth and fifth fingers were flexed at the interphalangeal joints and extended at the metacarpophalangeal joints. A certain degree of contracture existed in the metacarpophalangeal joints which limited flexion of these joints.

The roentgenogram of the right elbow was negative. The left elbow showed an old resection of the distal end of the humerus and of the proximal ends of the radius and ulna. The humerus was placed posteriorly and there was an anterior concavity in that bone into which the upper end of the ulna fitted. An anterior displacement of the two bones of the forearm existed. The bones showed reactive productive bony changes. Numerous round opaque bodies, smaller than a pea, were noted in the soft tissues about the joint, especially anteriorly. These were the shadows of the buckshot.

The operative problem was the restoration of lateral stability to the elbow joint. A fascial plastic operation which aimed to restore the ulnar collateral ligament was decided upon. The intent was to duplicate the natural formation of the ligament. This ligament begins at the medial epicondyle of the humerus and inserts from the medial part of the olecranon process to the medial part of the coronoid process. It consists of a stronger, thicker, triangular, anterior part and a weaker, posterior part. A transverse band joins these two inferiorly, bridging the notch between the olecranon process and the coronoid process.

The operation was done on September 23, 1936 under general anesthesia. A 6 inch longitudinal incision was made on the inner side of the elbow, extending about  $1\frac{1}{2}$  inches down on the forearm. The anteriorly displaced ulnar nerve was found easily beneath the deep fascia. It was isolated for about 4 inches on the arm. The flexor muscle mass was replaced by a dense white scar tissue which was split and the ulnar nerve traced through it to the fore-

arm. This was done with some difficulty since the nerve was adherent to the scar tissue. Its surface was broadened, ragged and irregu-



FIG. 1. Lateral roentgenogram of the left elbow joint. The humerus is displaced posteriorly and the bones of the forearm anteriorly. The shadows of buckshot are noted.

lar. The nerve was dead white in color, more opaque than normal. Neurolysis of the nerve was done at its point of passage through the scar tissue. The nerve was placed more anteriorly.

The lower end of the humerus and the upper end of the ulna were now exposed by an incision through the deep fascia. The humerus was displaced posteriorly. Each bone was well exposed by subperiosteal dissection. The joint itself was not opened. A drill hole was passed through the humerus from before backwards. A Y-shaped drill hole was made in the upper end of the ulna, the short stem of the Y being placed radially and horizontally. A ribbon-like strip of fascia lata, 7 inches long and  $\frac{1}{2}$  to  $\frac{3}{4}$  inch wide was stripped of fat and one end

tapered so that it could be passed through the humeral drill hole. It was carried through this hole by means of a loop of chromic catgut,

of Paris cast applied, holding the forearm in extension and in as much varus as possible, that is, the neutral position.

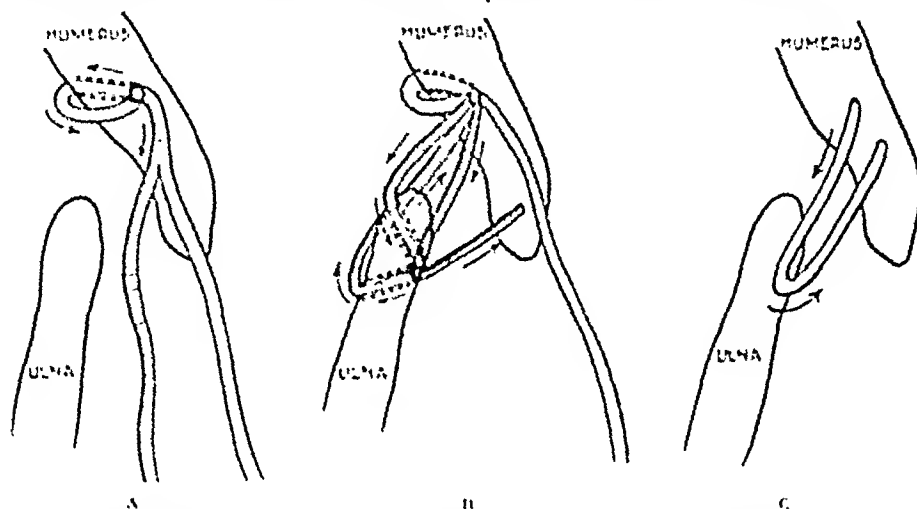


FIG. 2. The steps of the fascial plastic operation; a, the long strip of fascia was split longitudinally after it was passed through a drill hole in the humerus from before backward and sutured to itself, b, the passage of the radial shaded half of the split fascia through the Y-shaped drill channel in the ulna is indicated. The arrows indicate how the four-ply ligament was formed, c, the ulnar half of the split fascia forms a two-ply ligament. The reconstructed ligament is thus six-ply.

the direction of passage being from before backward. It was then sutured to itself anteriorly by chromic catgut. The strip of fascia was now split longitudinally for a distance of 6 inches, the point of splitting being joined by a single chromic catgut suture to prevent raveling or further separation. The radial part of the split fascial strip was now carried through the Y-shaped drill hole in the ulna, the direction of passage being from proximal to distal in the superior limb of the Y and then radial to ulnar in the inferior transverse limb of the Y. This fascia was then sutured under tension to the fascia on the lower end of the humerus, the forearm being held in extension and neutral as regards varus or valgus. This reinforcement was not strong enough to prevent lateral instability of the elbow on passive manipulation. Therefore, the radial strip was brought down to the ulna again and sutured there under tension. This made a three ply ligament of the radial half of the fascial strip. The ulnar part of the fascial strip was sutured to the ulna and then brought back to the humerus and anchored there. The remaining small stump of the radial strip was fastened transversely to the humerus and ulna. This six ply ligament now effectually prevented valgus movement of the elbow. The wound was closed and a plaster

The postoperative course was uneventful. The plaster was bivalved on November 12, 1936. The wound had healed by primary intention, but at a site removed from the operative field, in the transverse crease of skin beneath the prominent lower end of the humerus, a small sinus formed, which, on probing, led to an area of raw bone at the site of the drill hole in the humerus. The sinus was injected with a radio-opaque solution which, on anteroposterior and lateral roentgenograms of the joint, seemed to go to the drill holes in the humerus and ulna. Discharge from the sinus was always scanty. The sinus was frequently cauterized and injected with lipiodol. It closed spontaneously later.

On August 31, 1937, the elbow joint showed good stability so that the forearm could not be brought into a valgus position of more than 15 degrees passively, when the arm was held steady and the forearm abducted with strong force. There was still some pain on the inner side of the elbow due to stretching of the ulnar nerve. The arm was usually held at 150 degrees of extension and flexion was possible to 100 degrees. A brace which is articulated at the elbow protects the joint against undue strain. The elbow was stronger and the patient was able to carry a heavy pitcher of water or a pail

half full of water. The ulnar nerve lesion was unaltered. There was, however, some improvement in the ability to extend the end two phalanges of the fourth and fifth fingers.

Similar findings were noted at the last examination on May 18, 1939. The elbow was strong and useful. The brace was no longer worn.

#### SUMMARY

The case of a patient with a severe lateral instability of the left elbow is described, together with an operative

procedure to correct the instability in valgus. This was accomplished by means of a fascial strip so placed that it was made to duplicate the ulnar collateral ligament. The operation was indicated because the excess valgus of the elbow had given rise to a partial ulnar nerve palsy and to a strain epicondylitis of the right elbow. The elbow joint showed gross deformation after its ancient resection (fourteen years before) and its infection. The elbow is now stable and stronger and the patient able to carry weights.



THE difference between a clean wound which heals by primary union and an infected wound with suppuration, is the difference between days and weeks of economic loss.

From—"Surgery of the Hand" by Couch University of Toronto Press).

# UNUSUAL CASE OF TWIN PREGNANCIES

H. B. ELKINS, M.D.

Attending Obstetrician, Steptoe Valley Hospital

AND

R. A. BOWDLE, M.D., F.A.C.S.

Chief Surgeon, Steptoe Valley Hospital

EAST ELY, NEVADA

**T**HIS case is reported on account of the unusual findings of a twin pregnancy in which the uterine aborted and the

Vaginal examination showed an introitus readily admitting two fingers. The cervix was large and soft, the uterus enlarged to twice its



FIG. 1. Placenta intact.

tubal ruptured, with the fetus developing in the abdomen to die at term.

Mrs. E. V., age 38, white, was referred to the Steptoe Valley Hospital April 18, 1937 with a diagnosis of acute appendicitis. That morning, while using a bedpan, she had become nauseated and vomited. Severe abdominal pain had increased during the day. Three weeks prior to admission she had had several fainting spells with nausea, vomiting and general abdominal pains. A week later the patient had miscarried and her attending physician stated that the fetus and membranes came away intact, with a period of gestation, estimated at two months. Her past history was unimportant except that she had suffered several attacks of upper right quadrant pain which had been diagnosed as gall-bladder disease. Her menstrual history was normal and there had been no previous pregnancies.

Examination showed a very obese female weighing 236 pounds, retching constantly. Temperature was 97.4, pulse 120, full and regular, blood pressure 122/80, respirations 38, grunting and shallow. The abdomen was markedly distended in the upper portion; no masses were palpable, but there was generalized tenderness.

normal size, movable but tender. No masses were palpable, but there was moderate tenderness over the left tube and slight leucorrhea.

The urine was negative. The white blood count was 13,300 with 83 per cent polymorphonuclears. Other physical findings were essentially negative.

Under expectant treatment the patient fully recovered and was discharged from the Hospital May 1.

On August 8 she reported at the prenatal clinic, and a diagnosis of a seven months' pregnancy was made. There were no abnormal findings at this time. The patient reported regularly until she entered the hospital October 1, apparently in active labor. The fetal heart sounds were strong, rate 140. There was a vertex presentation, but the cervix was not dilated. The following day the pains had subsided and no fetal heart could be heard nor any fetal movement detected. Medical induction was tried unsuccessfully. X-ray showed a term pregnancy with vertex presenting. Vaginal examination showed the presenting part soft and high with no cervical dilatation. There was a slight bloody discharge. The patient was discharged from the hospital in excellent condition with a diagnosis of abdominal pregnancy with fetal death.

On January 4, 1938, February 1, and March 6, the patient had normal menstrual periods lasting four days. Her general health was excellent. She was referred to Dr. Alice F. Maxwell who confirmed the diagnosis and advised a laparotomy.

On April 18, the patient entered Steptoe Valley Hospital. Under spinal anesthesia a laparotomy was performed and a full term dead female fetus weighing  $6\frac{1}{2}$  pounds was found lying in the abdominal cavity. A few flimsy adhesions were separated between the fetus and the intestines. The fetus was macerated, deformed and the head partly collapsed. The placenta was large and sclerotic, with the left tube and ovary incorporated in it. The entire mass was firmly attached to the left pelvic wall. It was separated with only slight bleeding and was removed along with the left tube and ovary. A small fibroid on the anterior wall of the uterus was excised. The abdominal incision was closed in layers with two Penrose drains placed at the site of placental attachment. The patient made an uneventful recovery and was discharged from the hospital May 8. About three months later she reported for examination and a small hernia was found at the site of the drainage tubes. Her menstrual periods had been regular and her health better than for years previous.

#### CONCLUSIONS

It would seem that a diagnosis of an abdominal pregnancy should have been definitely made at an earlier date. The

thickness of the patient's abdominal wall, together with the confirmed miscarriage at two months, made the condition con-



FIG. 2. Fetus removed from abdomen.

fusing. We believe that the illness in April 1937 was due to the rupture of a left tubal pregnancy. With the death of the fetus and the patient in such good physical condition there seemed no indication for early surgical interference. The policy of conservatism was indicated in the hope that the placental site would either calcify or sclerose and the chance of severe hemorrhage at operation would thereby be lessened. This was borne out by the operative findings and the subsequent uneventful recovery of the patient.





# SUBCUTANEOUS RUPTURE OF THE STOMACH FOLLOWED BY A GASTRIC FISTULA

WILLIAM H. ERB, M.D.

AND

L. KRAEER FERGUSON, M.D.

Assistant Surgeon, University of Pennsylvania  
and Philadelphia General Hospitals

Surgeon, Philadelphia General Hospital

PHILADELPHIA, PENNSYLVANIA

**S**UBCUTANEOUS rupture of the stomach, as here presented, is independent of any preëxisting pathologic lesion, such as ulcer or carcinoma, and unassociated with penetrating wounds of the abdominal wall. This type of rupture may be traumatic or spontaneous, the latter being by far the less frequent in occurrence.

Petry,<sup>5</sup> in 1896, collected 219 cases of rupture of the gastrointestinal tract with only twenty-one cases of ruptured stomach. Sherren<sup>9</sup> reported 220 cases of abdominal contusion at the London Hospital with only five cases of ruptured stomach. Wolf,<sup>10</sup> in an excellent though not complete review of the literature in 1936, was able to collect sixty-eight cases to which he added one of his own. Of this number only nineteen recovered.

The anatomic position of the stomach protects it from injury and this probably accounts for the low incidence of rupture in abdominal contusions. Glassman<sup>3</sup> states that rupture, when it does occur, is most frequent at the pyloric end, which is the most exposed portion of the stomach.

The trauma necessary to produce rupture may be very severe, such as being run over by a truck, or very mild, such as in a child reported by Rodonachi<sup>7</sup> who simply caught her toe, fell and was able to walk one mile back to her home. In fact, as noted previously, rupture may occur without any trauma and such a case was reported by Gill<sup>2</sup> in 1917, being one of the seventeen reported in the literature.

The symptoms are usually those of shock, perforation and internal hemorrhage, and depend somewhat upon how long after the accident the patient is seen. Rehn<sup>6</sup> emphasized the value of hema-

temesis as a diagnostic sign but in many cases reported in the literature, as in our case, this did not occur.

Treatment is immediate surgery as soon as possible after initial reaction from trauma. Just<sup>4</sup> emphasizes the importance of a thorough exploration of the peritoneal cavity in order to rule out the possibility of some other complication. Quite frequently rupture of the stomach is accompanied by rupture of the liver, spleen or duodenum and, occasionally, contusion of the pancreas.

## CASE REPORT

M. R., colored female, age 37, was assaulted by a "boy friend" at about 8 P.M. on May 26, 1937. He demanded that she give him the \$5.00 which she had for her rent. She refused. Her irate friend pulled a wooden strip from a door facing and struck her across her left wrist leaving a "knot" (which was present on admission). She was then struck to the floor by a fist blow to the sternum. She struck no object in falling and was not unconscious. While she was lying on the floor, her assailant kicked her in the abdomen and left side, and beat her with the wooden club. Friends who lived in the same building told the patient they heard the beating continue until she gradually lost consciousness, as evidenced by cessation of screams and moans. She did not regain consciousness until 4 A.M. In the interval she had been moved to her daughter's home by the police.

She was attended by a physician who prescribed medicines, which afforded her some relief for about a week. She then began to have pain in her left side, which gradually became very severe. This was localized in the left upper quadrant, left flank and kidney region, and did not radiate. The pain was intermittent, described as "misery" and made her feel like rolling around on the floor. Vomiting occurred several times each day; only water and soup

could be retained. The vomitus consisted of undigested food and bile but never blood. Vomiting afforded relief from the "misery" for

derness in the left loin and flank. The liver and spleen were not palpable; kidneys not palpated. There was no other abdominal tenderness or



FIG. 1. Anteroposterior view showing sodium iodide outlining the stomach with a drainage tube apparently near the cardiac end of stomach.



FIG. 2. Lateral view after injection of sinus with sodium iodide solution. The drainage tube is shown fixed by safety pin. The iodide solution outlines the stomach, duodenal cap and descending part of duodenum.

a short time. The pain finally became sufficiently severe to cause the patient to come to the Philadelphia General Hospital on June 20, 1937, approximately four weeks after injury.

Specific inquiry at this time failed to reveal any history of indigestion prior to injury. Bowel movements had been regular, dark or light brown in color. There was no history of bright or dark blood in the fecal material. There had been no urinary frequency, dysuria or hematuria. In fact, in a systemic review, no further symptoms were elicited except pain, since injury, in the left lower chest on deep respiration.

The patient was well-developed but dehydrated, and appeared acutely ill. Her respiratory rate was alternately rapid and normal, apparently somewhat influenced by emotion. On admission, her temperature was 99, pulse 100, respiration 28 and blood pressure 120/90. The positive physical findings were faint ecchymosis over the left loin and marked ten-

rigidity, and peristalsis was present. As noted in the history, there was a nodular deformity over the lower left ulna.

*Laboratory Findings.* A flat plate of the abdomen showed no abnormalities. An intravenous urogram was also negative. A roentgenogram of the left ulna confirmed a diagnosis of fracture with fragments in good position and with considerable callus present.

On admission, the red blood cells numbered 3,580,000, the white cells 29,000, of which 88 per cent were polys, 10 per cent lymphocytes and 2 per cent transitionals. Hemoglobin was 65 per cent. The urine, except for a trace of albumin, was essentially negative.

The clinical impression at this time was an infected hematoma in the retroperitoneal space, possibly arising from a ruptured kidney. Therefore, on June 22 (two days after admission), a large aspirating needle was inserted in the midaxillary line at the level of the twelfth rib

over the area of maximum tenderness. Reddish brown pus with a distinct colon odor was obtained. Culture taken at this time showed no growth under aerobic or anaerobic condition, though the smear showed Gram-positive cocci. Using the needle as a guide, a large abscess cavity was entered, containing fully a quart of foul-smelling sanguinous pus. In enlarging the incision, the pleura was inadvertently nicked. This was immediately packed off. One large rubber tube, three Penrose drains and three pieces of iodoform packing were employed as drainage.

Following operation, the patient's temperature fell from 103 to normal, and remained subnormal for several days. Except for physical signs of a small pneumothorax, no complications resulted from opening of the pleura. However, her pulse was weak and rapid and she did not seem to recover as rapidly as one might expect after drainage of a simple hematoma. All drains, except one rubber tube were removed by the seventh day. The patient continued to drain large amounts of greenish fluid, the amount varying from day to day. No notation was made of any food particles in the drainage. Because of persistent draining, the sinus was injected one month after operation with sodium iodide solution. We were surprised to learn that the iodide solution outlined the stomach and duodenum. After this x-ray demonstration of the relation of the sinus to the stomach, the intern remembered the patient had stated on one occasion that she could taste the Dakin's solution with which he irrigated the cavity. Since he did not consider this possible, he had not mentioned it to anyone.

The tube was withdrawn, drainage promptly became less and the wound started to close rapidly. A gastrointestinal series taken one week after removal of the tube failed to show any defect and the stomach was reported as normal. The patient was discharged on July 31, 1937, eleven days after the establishment of

the diagnosis, with the wound partially closed. It healed completely without any further complications and the patient gained weight and was in perfect health in April, 1938.

#### DISCUSSION

We believe this patient had a rupture of the posterior stomach wall with the formation of a walled-off abscess in the lesser peritoneal sac. One might possibly consider that the original injury was simply a contusion with the formation of a hematoma which later became infected and eroded into the stomach. However, one would hardly expect as rapid nor as complete healing, without x-ray evidence, of any defect in this type of perforation. Rose<sup>8</sup> reports a somewhat similar case except that this patient was drained through the gastrocolic omentum two weeks after injury. Ettmuller<sup>1</sup> reported two cases of gastric fistulae developing after trauma, which healed spontaneously. The fact that gastric fistulae tend to heal spontaneously unless proximal to a point of obstruction is shown by our case as well as by the above-mentioned three cases. The value of investigating a draining sinus by the injection of an opaque medium is also emphasized by this case.

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# HODGKIN'S DISEASE OF THE INTESTINE PRODUCING INTESTINAL OBSTRUCTION

CHARLES C. SPANGLER, M.D.

Late Surgeon, York Hospital

YORK, PENNSYLVANIA

THE outstanding feature of the present day conception of Hodgkin's disease is the histopathology of the affected nodes, upon which alone a positive diagnosis—in the light of current knowledge—can be made. Whether the exciting cause of the entity is an infectious granuloma or a malignant neoplasm is still unknown. A historical review of the entity may be conveniently divided into two periods, the first embracing the years 1832 to 1898, the second extending from the latter year until the present time. The first period began with the publication of Hodgkin's work 1832 and despite the abundant literature of this period, we may say that but little progress was made toward the obtaining of data which today, we consider essential to a proper appreciation of the condition. Bonfils (1856) spoke of it as a cachexia without leucemic changes. Virchow (1865) allied it with the lymphosarcomata. Cohnheim called it pseudoleucemia (lymphadenoma without leucemic changes). The majority of the early observers regarded it as some form of malignancy as is evidenced by Billroth (1869) who called it malignant lymphoma; Langhans (1872) malignant lymphosarcoma; Schultz (1874) reticulated desmoid carcinoma; Orth (1887) malignant lymphadenoma; and Langebeck called it gland sarcoma.

The second historical period, corresponding to the present century, comprises the greater part of the research which has given us a definite histopathologic picture of the disease. Briefly we have learned that pseudoleucemia is not a scientifically appropriate name for Hodgkin's disease, and that the large group of generalized lymph node enlargements can be divided into three distinct groups; the granulomata

which include Hodgkin's disease, tuberculosis and syphilis, the true neoplasms, which are chiefly of a sarcomatous nature, and the leucemias. The sometimes used interchangeable terminology of pseudoleucemia and Hodgkin's disease is erroneous, because Hodgkin's disease is a true leucemia. Even today although the pendulum of opinion has swung strongly and generally toward emphasizing the infectious character of the disease, it seems apparent that the process has many of the earmarks of malignancy.

Hodgkin's disease of the gastrointestinal tract is a rare entity. Up until 1930 the literature disclosed only twenty-eight cases; of these, sixteen patients were operated upon and in the remaining cases the disease was not revealed before necropsy. Reported isolated involvement of the gastrointestinal tract has been observed only eight times. Bunting has said that of all the forms of Hodgkin's disease those of primary involvement in the abdomen are most obscure. It is said that the immunity of the gastrointestinal tract to Hodgkin's infiltration was formerly used as a criterion to differentiate this disease from lymphosarcoma. Hodgkin's disease may involve any portion of the gastrointestinal tract though the small bowel is most frequently involved and the esophagus least frequently.

There is a striking similarity of the gross and microscopic findings in gastrointestinal Hodgkin's disease and lymphosarcoma. Clinically very few diagnosis have been made. This is due to several factors. Probably the greatest obstacle to clinical diagnosis is the lack of any positive physical findings, which together with the indefinite and multiple symptoms and

the rarity of the disease makes clinical diagnosis almost impossible. It may simulate a number of acute and chronic conditions as tubercular peritonitis, typhoid fever, lymphosarcoma of the retroperitoneal glands and the splenomegalies, particularly leukemia and splenic anemia and occasionally from splenomegaly of the Gaucher type, Banti's disease and von Jaksch's anemia. Hodgkin's disease involving the gastrointestinal tract differs from the hyperplastic type of tuberculosis in that it tends to occur in the upper portion of the small intestines while tuberculosis affects primarily the lower ileum and cecum. Ulceration and perforation with resulting peritonitis occasionally occurs and the lesions are usually multiple, though rare instances of single lesions have been reported. In contradistinction to the general disease, the spleen and liver are usually not enlarged, though there seems to be a variance in these reports. The retroperitoneal and mesenteric lymph nodes are usually enlarged. The liver is much less frequently involved than the spleen and this fact suggests that the disease may be primarily in the spleen. Complications such as perforation, hemorrhage and intussusception may occur.

The age of greatest incidence in gastrointestinal Hodgkin's disease corresponds about to that of the disease in general. It occurs during the fourth and fifth decades of life, more commonly in males than females. The onset is insidious. Later the symptoms may be abdominal pain, diarrhea, cachexia, anorexia, night sweats, ascites, pain in the legs, lassitude, jaundice, pruritus, constipation, anemia and fever of the intermittent type. The patient may, however, run an afebrile course.

There is nothing in an occasional blood picture, but an average based on repeated blood examinations reveals a fairly definite picture as reported by Bunting, Yates and others that there occurs first an early lymphocytosis, giving way to a polymorphonuclear leucocytosis, and an increase in the transitional cells and blood platelets.

The latter two are the most significant findings. The literature seems to indicate that the prognosis in Hodgkin's disease is hopeless.

The only treatment that has proved of any value is radiotherapy, the benefit of which is usually most noticeable in the early cases, especially those in which the glands have not yet become fibrous.

#### CASE REPORT

The patient, a boy 11 years of age, was admitted to the York Hospital January 16, 1937, complaining of general abdominal pain, slight abdominal distention and vomiting. After three hours the pain became more localized in the right hypogastrium. His temperature was 99 and his pulse rate 100. Except for slight constipation the patient enjoyed perfect health until his admission to the hospital. Shortly after his admission to the hospital he vomited fecal matter. Palpation of the abdomen revealed tenderness with rigidity in the right lower quadrant of the abdomen and a palpable mass. A tentative diagnosis of intestinal obstruction, with a probable appendiceal abscess, was made.

A right rectus incision was made. An intussusception at the ileocecal valve was noted. At that point approximately 2 feet of ileum was intussuscepted through the cecum and into the ascending colon. This was reduced with difficulty due to the edema of the walls of the ileum. The circulation was fair and no resection was deemed necessary. The appendix was found to contain a fecal impaction and it was removed.

The laboratory reported a mild chronic inflammatory response in the appendix, characterized chiefly by interstitial lymphocytic infiltration throughout all strata of the appendiceal wall. Chronic appendicitis with appendiceal (fecal) concretion was the diagnosis.

The patient made an uneventful recovery and was discharged from the hospital January 23, 1937. He continued in perfect health until July 25, 1938 when he was again admitted to the hospital complaining of general abdominal pain, nausea, vomiting and diarrhea. His temperature was 99 and his pulse 80. He was given a castor oil enema and kept under close observation for forty-eight hours, during which time his symptoms all disappeared. He was discharged July 27, 1938.

On August 22, 1938 he was again admitted to the hospital. On August 19 he complained of

abdominal pain chiefly over the line of his previous incision to the right of the midline of the abdomen. The pain became progressively worse and nausea and vomiting occurred. On the day of his admission to the hospital he vomited fecal matter. His temperature was 99, pulse 80. The total red count was 4,550,000 and the white count 19,000.

An intestinal obstruction appeared probable and on August 22 the abdomen was opened by a midline incision from umbilicus to symphysis pubis. About  $1\frac{1}{2}$  feet above the ileocecal valve, a loop of ileum was adherent to the anterior abdominal wall, producing a kink and complete obstruction, the bowels being collapsed below this point. The adhesion was released and the kink freed. Upon further investigation a second obstruction was found about  $1\frac{1}{2}$  feet above the first adhesion, this obstruction being caused by a loop of omentum bound around a section of ileum. This adhesion was released. About  $1\frac{1}{2}$  feet above this point a neoplasm was discovered in the lumen of the ileum. The tumor mass was perfectly smooth and round, and seemed to be adherent to the inner intestinal wall, producing a complete obstruction of the lumen of the intestine. Approximately 7 inches of the ileum, including the tumor mass, was removed and the ileum united by the end-to-end method. Further investigation of the intestinal tract revealed no other pathology. There was no evidence of splenic, liver or other glandular enlargement. The patient was discharged from the hospital September 7, 1938 completely healed and in good condition.

X-ray examination of the chest revealed no evidence of pulmonary disease.

*Pathologic Report.* The section of ileum was fixed in formalin. A nearly spherical tumor, 1.8 cm. in diameter, having a submu-

eous location, projected into and completely occupied the cross section of the lumen. It was sharply demarcated from the compressed musculature and overlying mucosa on bisection. The cut surface was homogeneously solid, firm and white. The overlying mucosa was hemorrhagic and at one point presented a rather superficial ulcer 2 mm. in diameter. There was no hypertrophy of the musculature at either side of the tumor.

The nodule was sharply confined to the submucosa, although it displaced and compressed both mucosa and musculature. It was moderately and heterogeneously cellular, being composed of fibroblasts, mature fibrous connective tissue, histocytes of variable type and a few lymphocytes. There were macrophage histocytes, plasma cells, mononuclear eosinophiles and also large cells with bulky, single and multiple, pale, vesicular nuclei and prominent nucleoli. These have been variously designated Dorothy Reed cells and Sternberg cells, and are characteristic of Hodgkin's Disease. The pathologic diagnosis was Hodgkin's disease of the ileum.

#### COMMENT

This case is unusual in that: (1) Hodgkin's disease is limited entirely to the abdominal cavity; (2) has invaded only the ileum as a single lesion with no mesenteric or retroperitoneal glandular involvement; (3) occurs at the age of 13 instead of as usual in the fourth or fifth decades. It was associated with intestinal obstructions and was preceded by an intussusception nineteen months prior. Its afebrile course is unusual, with no evidence of cachexia, anemia or palpable glands.



# CHRONIC INFLAMMATORY TUMORS OF THE ILEOCECAL SEGMENT\*

## WITH CASE REPORT

RALPH H. FOUSER, M.D., F.A.C.S.

Clinical Associate in Surgery, Rush Medical College of The University of Chicago

CHICAGO, ILLINOIS

**I**NFLAMMATORY or "pseudotumors" of the bowel were described by Virchow in 1853. Thereafter reports of clinical cases became numerous in the literature. The case reports of the British surgeons Moynihan, Mayo-Robson and Dalziel called attention to these tumors. Braun added further to this study by his report "Über entzündliche Geschwülste am Darm." Lawen made an extensive study and advanced the view that "the majority of chronic inflammatory tumors of the cecum arise from a chronic fibroplastic inflammation of the appendix."

Moschowitz and Wilensky in 1923 established chronic nonspecific inflammation of the intestines as a clinical and pathologic entity. Bouman in 1924 reviewed the literature up to that date.

James states that Dalziel in 1913 was aware of an entity which he described as "chronic interstitial enteritis." Little attention was focused on the condition, however, until 1932, when Crohn, Ginzburg and Oppenheimer described a subacute or chronic inflammatory condition affecting the terminal portion of the small intestine which they termed "regional ileitis." He further states that several contributions have appeared since, but very little has been added to our knowledge of the disease. In most of the cases described, the lesion has shown a predilection for the terminal portion of the ileum, but any part of the intestinal tract may be involved; there have been very few examples of isolated involvement of the colon.

Ralphs states that following the report of Crohn, Ginzburg and Oppenheimer in 1932,

a sequence of case reports by many writers has appeared with a multiplicity of titles, e.g., "localized hypertrophic enteritis" (Jackman), "chronic hyperplastic enteritis," "chronic cicatrizing enteritis" (Barbour and Stokes), and so forth. More recently Lawen has added to his earlier studies and reports by stating that microscopic features of the entity which he described in 1914 under the name fibroplastic appendicitis are identical with those of terminal ileitis described in 1932 by Crohn, Ginzburg and Oppenheimer.

Lawen had stated in his description that fibroplastic appendicitis may involve the cecal wall and the terminal portion of the ileum and thus lead to a secondary terminal ileitis. He concludes that the tumor-forming, chronic stenosing, ulcerative or nonulcerative ileitis and fibroplastic appendicitis and the analogous disorders of the ascending colon present an identical microscopic picture. They represent the same type of inflammation with a different primary localization.

It is a well recognized fact that chronic nonspecific inflammation may occur in any portion of the gastrointestinal tract. However, it occurs most frequently in the ileocecal region. Larimore has stated two reasons for such frequent predilection for this region. First, the cecum and cecocolic segments of the large intestine are subject to inflammatory reactions of degrees varying from simple catarrhal irritations to extensive ulcerations by bacterial invasion of the walls. Secondly, most bacterial growths are due to slow segmental transport and greater fluidity in the ileocecal segment.

\* From the Surgical Service, West Suburban Hospital, Oak Park, Illinois. Read before the Surgical Staff of the Hospital.



## CASE REPORT

L. A. V., aged 26, a housewife, complained of pain in the lower abdomen. Two months before she had had a first attack of severe pain in the region below the umbilicus and in the lower right abdomen. The attack lasted about three days and was not accompanied by nausea or vomiting. The pain had no relation to food intake or her menstrual period. Since this attack there had been several others at four to five day intervals which lasted for a few days. Soreness in lower abdomen persisted between attacks. The pain was aggravated by walking. There had been considerable constipation and bowel distress. The patient further stated that for about three years she had had mild attacks of pain in the lower right quadrant with gastric upsets.

The past history was essentially negative.

Physical examination revealed an obese, well-developed white female, with temperature of 100.4 degrees and pulse of 92.

Abdominal palpation revealed a heavy panniculus and symmetrical abdominal wall. A tender, fixed mass about the size of a small grapefruit could be palpated in the region just below and to the right of the umbilicus. Bimanual examination revealed an infantile uterus, a mass in the lower right abdomen and pelvis which also involved the right uterine tube and the right ovary.

The blood count was within normal limits.

The diagnosis made was chronic inflammatory tumor of the cecum, appendix, right uterine tube and right ovary.

*Operation.* A right paramedian incision was made from a point lateral to the umbilicus down to the pubic region. The deep fascia was covered with a layer of subcutaneous fat of approximately 10 cm. thickness. The fascia was incised and the edges dissected from the underlying muscle tissue. The recti muscles were separated and the peritoneum incised to the right of the midline. The lower portion of the greater omentum was found to be closely adherent over the anterior and medial surfaces of the tumor mass. The omentum was clamped, cut and ligated and the adherent mass of distal omentum carefully dissected free from the underlying tissue mass. The abdominal and pelvic cavities were explored and the mass outlined in the cecal region which involved the cecum, terminal loops of ileum, appendix,

mesentery, lateral pelvic wall, right tube and the right ovary. Upon examination it was found that the left tube was essentially negative, the left ovary was small and fibrotic, and the uterus was infantile in size and outline. All structures involved in the mass were closely adherent to each other by the infiltration and abundant overgrowth of dense white fibrous connective tissue.

The right tube and ligament of the right ovary were dissected free from the mass by finger dissection, clamped with considerable difficulty, cut and ligated with fixation sutures of No. 1 plain catgut. The herniated loop of the terminal ileum was then carefully dissected free from the position of its attachment under the mass and above the region of the right tube. This loop of ileum was partially obstructed due to its herniated position. The most distal loop of terminal ileum was separated from the medial surface of the mass by finger dissection. Dense white fibrous connective tissue abundant in quantity characterized all the adherent attaching tissue. The appendix was located with difficulty in a retrocecal position, intimately related to the wall of the mass. Owing to its large size and hard, fibrous consistency, it was separated with great difficulty from the cecum; an appendiceal artery was cut and ligated with fixation suture. It was not possible to ligate the appendix because of its size and the density of the tissue. The appendix was removed at its base from the wall of the cecum, which was very friable, markedly thickened and firm in character. A cecostomy was done by the insertion of a rubber tube in the appendiceal opening of the cecum, fixed by a purse-string and interrupted sutures of chromic No. 1 catgut. All raw surfaces were peritonealized as much as possible. The omental tissues were drawn down and placed in the region of the cecostomy. A rubber Penrose drain was inserted to the right pelvic region. The peritoneum was closed with plain No. 1 catgut. Four silkworm gut retention sutures with buttons were placed in the skin, subcutaneous and fascial tissue.

The fascia was closed with chromic No. 1 catgut. Two thin rubber tissue drains were placed in the subcutaneous tissues, one at each extremity of the incision for fat drains; four interrupted subcutaneous sutures of plain No. 1 catgut were inserted. The skin was closed with interrupted silkworm gut sutures. The cecos-



tomy extended through the midincisional region as the immobility of the cecum prevented a right stab incision in the lateral abdominal

a herniated position under the mass and above the uterine tube. This loop was partially obstructed; no gangrenous areas were present.

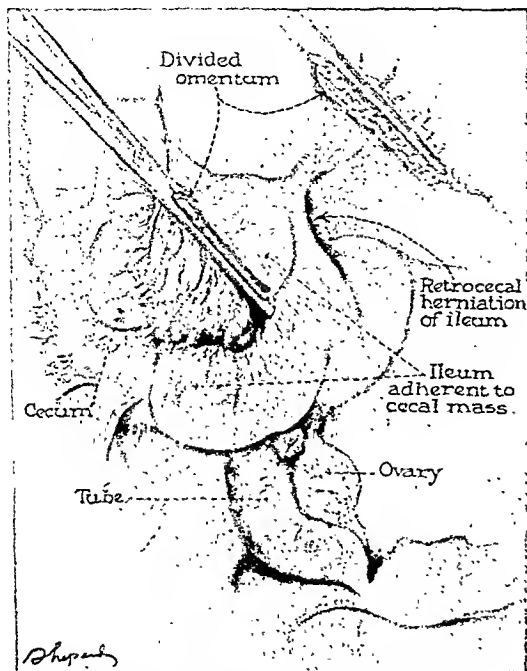


FIG. 1. Drawing of tumor mass in cecal region. The terminal ileum is adherent to the cecal tumor. A portion of the terminal ileum is herniated and partially obstructed. The right uterine tube and right ovary are adherent to the tumor mass. Dense fibrous connective tissue adhesions are shown which attach the tumor mass to the parietal peritoneum and pelvic wall. The adherent lower portion of the omentum has been clamped and cut.

wall. A silkworm gut retention suture was used at the skin margin of the incision to hold the rubber tube in position.

**Pathologic Report.** The specimen removed consisted of a hard mass the size of a small grapefruit in the cecal region, which extended medially to the midabdominal region. It consisted of a markedly enlarged cecum with the lower portion of the greater omentum adherent to the underlying mass. The cecal walls were much thickened and indurated; the terminal loop of the ileum was adherent to the mass; the appendix with no apparent lumen except at its base was markedly enlarged and densely fibrotic. The appendix was in a retrocecal position and closely adherent to the cecal wall by an overgrowth of dense fibrous connective tissue. The mesoappendix had been replaced and obliterated by dense white fibrous connective tissue. A loop of the terminal ileum was in

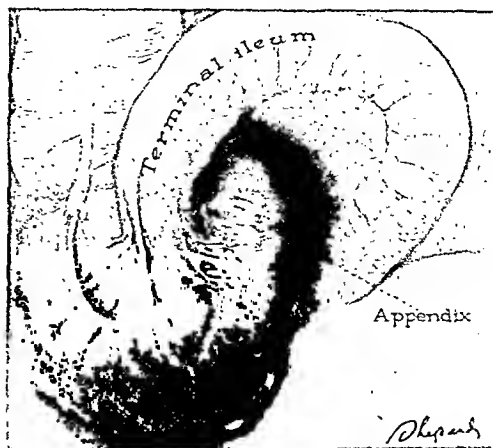


FIG. 2. Cecal tumor and markedly enlarged and adherent appendix. The adhesions have been dissected, releasing the adherent terminal ileum from the tumor mass. The loop of ileum is elevated to expose the appendix which is in a retrocecal position. The right uterine tube and right ovary have been removed.

The mass was adherent to the lateral pelvic wall by the infiltration of dense fibrous connective tissue which extended downward to the region of the iliac vessels. The mesenteric tissues were thickened and very firm and nodular due to the fibrous infiltration.

Sections of the appendix and tube revealed the characteristic appearance of a chronic inflammatory lesion. There was an abundance of fibrous connective tissue which had replaced the tissues which make up the walls of the appendix and intestine. This replacement was most evident in the submucosa and muscularis layers. The tissues were invaded by neutrophils, eosinophiles and lymphocytes. The sections of the mesentery and ovary presented the same pathologic changes—those of chronic proliferative inflammation.

The patient made an excellent recovery. The cecal tube was removed the tenth day. There was a small amount of drainage from the site of the tube for a number of days, after which time the opening in the tissues closed. The patient has had no distress; her appetite is good and her bowels regular. The patient's health has been excellent since operation.

**Etiology and Pathology.** James states that nothing definite is known regarding

the etiology of the disease. Although it is quite generally agreed that the origin is infectious, no specific organism has been recovered from the feces, the affected intestinal wall, or the lymph glands.

Braun has called attention to the fact that chronic nonspecific inflammatory tumors of the intestinal tract may be caused by streptomyces as well as staphylococcosis and infections with the *Bacillus coli*.

Mailer reported *Streptococcus viridans* as a possible infective agent. It is well recognized that *Streptococcus viridans* is capable of producing a relatively low-grade inflammation similar to that present in these tumor masses.

Ralphs emphasizes the frequency of a lesion of the mucosa as the portal of entry for the infection. He further states that through some break in the mucosa the submucosa is involved and becomes the seat of a marked inflammatory reaction with round-celled infiltration. Although the path of the infection may be via the mucous membrane, it is possible to be from without, as well. The muscularis may be penetrated. Mural infiltration may be complete, and an infiltrated and thickened serosa may cause contact adhesions to the parietes, adjacent organs, neighboring loops of bowel, or the retroperitoneum.

Kirschner and Nordmann present further etiologic evidence, quoting the view of Lawen that "the majority of chronic inflammatory tumors of the cecum arise from a chronic fibroplastic inflammation of the appendix." Their own observations confirm these facts in that chronic appendicitis of slow development may transform the cecum into a tumor of wooden consistency and fuse the cecum to the retroperitoneal tissues by a cartilaginous induration.

It may be stated that the literature is in quite general agreement in the following fact, namely, the proliferating fibroplastic tumors in the ileocecal region are the result of a low-grade inflammatory process insidious in nature and extending over a period of months or years.

**Diagnosis.** The differential diagnosis may present a very difficult problem. The specific inflammations (tuberculosis, syphilis, actinomycosis) and malignant disease may cause intestinal tumor masses which are difficult to differentiate from nonspecific inflammatory masses before operative exploration. Pathologic examination and histologic studies are the determining factors in the more complicated cases.

**Treatment.** The operative procedure must be based upon the extent of the pathologic involvement and the judgment of the operating surgeon.

Ralphs has stated that resection of the tumor mass is the ideal course, but this is often impracticable due to the presence of adhesions to adjacent structures and the retroperitoneal tissues. Meyer and Rosi have resected wherever practicable. Short circuiting anastomoses have been employed with success by Hodgson. Cases of a less involved nature have been reported where spontaneous recovery has taken place following simple exploration.

#### SUMMARY

A brief review has been made of the literature on chronic inflammatory tumors of the ileocecal region.

A case has been recorded of an ileocecal tumor mass which presented an extensive involvement of the adjacent structures as the result of a chronic proliferative inflammation.

The mass was not resectable. The appendix, ovary, uterine tube and a portion of the mesentery were surgically removed. A cecostomy was done for drainage of the cecum.

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PERIARTERITIS nodosa is a rare form of arterial disease. . . . It is presumably an infectious disease of the medium sized and smaller arteries, characterized by fever, pain, and nodules along the course of the vessels. From—"Peripheral Vascular Diseases" by Kramer (Blakiston).

# TRAUMATIC RUPTURE OF THE SPLEEN WITH DELAYED HEMORRHAGE

## REPORT OF A CASE

EMERSON J. STEENROD, M.D.

IOWA FALLS, IOWA

**D**ELAYED hemorrhage from a traumatic rupture of the spleen may come as a surprise to the surgeon unless he anticipates its onset by the type and location of the initial injury. This condition presents a serious abdominal catastrophe which must be recognized and treated at once if the patient is to survive.

In 1931 McIndoe<sup>7</sup> collected and reported forty-six cases of delayed hemorrhage from ruptured spleens. He purposely omitted all cases which presented primary rupture of the spleen with immediate symptoms. Since 1931 I have been able to collect seven additional cases<sup>1,2,3,4,5,6,8</sup> from the literature. The one I am presenting in this paper makes a total of fifty-four reported cases. Of the fifty-four, operation was performed in forty-five with a mortality of 25 per cent. Eight patients died on the table or within forty-eight hours, from hemorrhage and shock; one died on the seventh day from peritonitis; one from bronchopneumonia on the third day; and one died on the twenty-ninth day from intestinal obstruction. There were nine patients not operated on; of these, eight died and one recovered.

This type of injury may occur at any age, and is especially to be looked for after a blow or a crushing type of injury over the left lower thorax, particularly when evidence of fractures of one or more of the left lower ribs is discovered by physical examination or roentgenographic studies. Balance's sign of dulness in the left flank when present should be carefully investigated each day to determine whether there is any progression or regression in the extent of the abnormal percussion note. The spleen may rupture at the time of the initial injury and bleed within the capsule until the pressure is sufficient to burst the

capsule and cause the signs and symptoms of an internal abdominal hemorrhage. There is no specific time limit set for the splenic capsule to rupture; it may occur hours or days after the initial injury. If there is a history of trauma to the left side of the lower thoracic cage, or upper left side of the abdomen, or if fractured ribs on the lower left side of the thorax are encountered in the presence of delayed internal abdominal hemorrhage, the most likely cause is a ruptured spleen.

## CASE REPORT

A lineman, aged 20, was brought to the Hampton Clinic on June 28, 1938. He had severe pain in the left side of his chest and second and third degree burns about the body. He had been working on a high tension line (7,000 volts) and had noticed that a cut out on a transformer had blown out. It had been impossible to use a "hot stick" to apply a fuse, so he had climbed up a pole in an attempt to insert the fuse. His spur had slipped and in order to support his body he grasped a high tension wire and had immediately fallen 30 feet to the ground. He was unconscious for approximately three minutes. First aid was given by a local physician at the site of the accident and he was then brought to the Hampton Clinic.

The man was in severe pain, but he was well oriented and responded to questions. He did not show evidence of shock. The pulse was 104 beats per minute, the respirations 20 per minute, and the temperature by mouth 99.4°F.

The head and neck were essentially normal. The respirations were mostly abdominal in type and there was a marked lag of the left costal margin. Resonance was increased over the entire left chest. There was a shift of mediastinal dulness approximately 1 cm. to the right of the lateral margin of the sternum. The

breath sounds were absent over the entire left side of the chest. The right lung was normal.

The abdominal muscles were rigid, but no tender areas were palpated. Peristalsis was audible. The percussion note was equally tympanitic over the entire abdomen. There was tenderness along the left tenth rib both to the left of the vertebral column and in the mid-axillary line.

Second and third degree burns had occurred on the lateral palmar surface of the right hand and over the upper part of the left chest.

The leucocytes numbered 20,000 per cu. mm. of blood. The urine was normal. Roentgenographic examination of the thorax disclosed a partial left pneumothorax and a comminuted fracture 1.5 cm. lateral to the head of the left tenth rib with a greenstick fracture near the angle of the same rib.

A diagnosis was made of traumatic left pneumothorax, multiple fractures of the left tenth rib, and second and third degree burns about the body and upper extremities.

The patient was put to bed and observed. The left side of the chest was strapped with adhesive tape, careful debridement was performed on the burns. The remainder of the treatment was symptomatic. Convalescence was uneventful until the ninth hospital day. Roentgenographic studies of the thorax made on July 7, 1938 showed the left pneumothorax to be subsiding.

On the ninth day the patient suddenly developed severe epigastric pain, vomited, and went into shock. His temperature was 99.6°F., the pulse numbered 128 beats per minute, and the blood pressure fell from 120 systolic to 70. A diagnosis of concealed abdominal hemorrhage was made, probably from a ruptured spleen. After ten or twelve hours the patient became progressively worse, with dulness in both flanks and a demonstrable fluid wave in the abdomen. A blood transfusion was given and operation performed.

Under local anesthesia, the abdomen was opened through a modified upper left Kocher incision. When the peritoneum was opened blood was encountered. Exploration revealed a rent 1½ inches in diameter in the capsule at the lower pole of the spleen with contused oozing splenic tissue protruding through the hole. The spleen was three times normal size and much more soft and irregular in contour than the normal. The spleen was removed,

carefully avoiding injury to the tail of the pancreas. The pedicle was doubly ligated, as were several bleeding points on the greater curvature of the stomach. Further exploration was impossible because of the patient's general condition. The splenic cavity was packed with gauze, and the abdomen was closed in layers. Another blood transfusion was given during the operation.

Following operation, the general condition was very poor: temperature was 103.6°F., and pulse 146. During the next seven days the temperature and pulse gradually dropped to normal. On the seventh postoperative day pain in the right lower quadrant of the abdomen accompanied by nausea and vomiting suddenly appeared. This was followed by separation of the lower end of the wound. A piece of small bowel presented through the separation. When it was forced back into the abdomen the pain subsided. The wound was then reopened under local anesthesia and a secondary closure performed. This did not relieve the nausea and vomiting, so duodenal drainage was begun. The abdomen remained scaphoid, but it was impossible to obtain anything by way of the large bowel other than fragments of a clay colored stool. The picture was one of high intestinal obstruction. With duodenal drainage, intravenous fluids, and blood transfusions the patient remained fairly comfortable although there were both physical and roentgenographic signs of a bronchopneumonia in the right lung. Roentgenographic studies of the abdomen revealed distended loops of small intestine.

After twelve days of conservative treatment without any signs of improvement in the intestinal obstruction the abdomen was again opened under local anesthesia through an upper right rectus incision. Loops of reddened and distended jejunum were encountered. There were multiple adhesions about the abdomen, but the main site of obstruction was a large mass of adhesions in the splenic fossa, as well as many tight fibrous bands between loops of jejunum and ileum. Many of these bands were separated, but an enteroanastomosis around the mass of adhesions was impossible. The abdomen was closed. Following the operation the patient developed a generalized peritonitis and died on the seventh postoperative day, twenty-nine days after splenectomy and thirty-nine days after the initial injury.

A post-mortem examination of the abdomen revealed the omentum to be wrapped around the splenic flexure of the colon and upper jejunum and bound tightly in the region where the spleen was removed. There were multiple adhesions between loops of small intestine. The appendix was normal. The abdominal cavity contained purulent fluid.

#### SUMMARY

A case is reported of a traumatic rupture of the spleen in which the hemorrhage was delayed until nine days after the initial injury. This illustrates the importance of observing individuals with signs of injury about the left lower chest for a sufficient period of time before dismissal from the

hospital. This man had no complaints and was able to get out of bed when the catastrophe occurred.

Some interesting complications are described.

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## BOOK REVIEWS

HARVEY CUSHING'S SEVENTIETH BIRTHDAY PARTY. Published for The Harvey Cushing Society. Springfield, Ill., 1939. Charles C. Thomas. Price \$3.00.

This small, well printed volume contains the speeches, letters and tributes delivered on Harvey Cushing's seventieth birthday, April 8, 1939. Many physicians, his former pupils, old friends, most of them outstanding in the American medical scene, journeyed to New Haven (Connecticut) to do him honor. It was, we read, "A record of a gay and happy occasion." No one dreamed that not many months later he would be gone.

In this volume are the speeches, letters and tributes given in honor of a great pioneer in surgery, a teacher of parts and a gentleman. It permits those not present at that function to share in much of the warmth and "gay intimacy of the occasion." A most interesting chapter is that by Henry R. Viets entitled, "Notes on the Formative Period of a Neurological Surgeon." There are many illustrations; those done by Dr. Cushing himself in his case histories are gems. This volume is a beautiful tribute to a great American surgeon and will be guarded on the shelves of private and public libraries.

TREATMENT OF CANCER AND ALLIED DISEASES. By 147 Authorities. Edited by George T. Pack and Edward M. Livingston. In Three Volumes. New York, 1940. Paul B. Hoeber, Inc. Price \$36.00 per set.

The editors of this valuable and monumental work, as well as the authors, rightly deserve all the praise one can bestow upon them. They have done a good job. Books of this type usually leave much to be desired. However, after carefully going through each of the three volumes, we venture no criticism. To do so would be to pick out very minor flaws and unimportant non-essentials. In these times it takes courage for a publisher to bring out such a large scale work, but if merit deserves any reward then the

returns will more than compensate for the energy, labor and brains put into the task.

In the preface we read, "The purpose in the preparation of these volumes has been to create a reservoir of existing knowledge on the treatment of cancer and allied diseases from which any physician, who deals with these conditions, may conveniently draw. The object has been to pool at a common source and to bring together in one work the great mass of detailed information that has now accumulated concerning the techniques of cancer therapy in current use." This work lives up to every word of this thesis. It is a harmonious correlation of all accepted techniques of cancer therapy or treatment in current use. It also deals with the care of patients suffering from advanced cancer. In fact, the treatment of cancer in various parts or organs of the body and in all stages of the disease is reviewed and leaves nothing to be desired.

Volume One is divided into seven sections which cover introduction, general principles of treatment, mouth and pharynx, larynx, neck, thyroid and para thyroid, breast, and chest. Volume Two has six sections: esophagus, stomach, intestinal tract, colon, rectum, and female genitals. Volume Three has eight sections: urinary system, male genitals, skin, eye and orbit, nervous system, bone and synovial membranes, lymphoid system, and miscellaneous.

There are 2,598 pages of text and the authors have appended references at the end of each chapter. The illustrations number about 1,500 (on the whole they are excellent), and there is an ample index.

Inasmuch as cancer stands second in the column of causes of death in this country, and inasmuch as only a minority of the profession are familiar with all the phases of diagnosis and treatment, and inasmuch as this is the outstanding work of this year, standing in a class by itself—the only complete work on the subject—it would seem logical that a large number of physicians should have these volumes in their libraries.



S P E C I A L   S Y M P O S I U M

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# FRACTURES OF THE SHAFT OF THE FEMUR

*Papers Read at the Annual Meeting of the American  
Orthopaedic Association, Buffalo, New York,  
June 5-8, 1939*



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# EMERGENCY TREATMENT AND TRANSPORTATION SPLINTING OF FRACTURES OF THE FEMUR\*

FRANK D. DICKSON, M.D.

KANSAS CITY, MISSOURI

IN 1927, nine years after the World War, W. Rowley Bristow of London presented a paper before the Orthopaedic Section of the American Medical Association, entitled "The Influence of War Surgery on Fracture Treatment in Great Britain." It is a significant fact that twelve years later in discussing fractures of the shaft of the femur, it is again necessary to refresh our memory of the lessons the late War held for those who make fracture treatment a large part of their practice. These lessons are important at the present time for two reasons: first, because, owing to modern living conditions, severe fractures, occurring under circumstances simulating those of wartime, so far as emergency treatment and transportation are concerned, are on the increase; and second, because we are today living among wars and rumors of war, and no matter how unwilling we may be to admit it, no one can tell when the need may arise for putting into practice the lessons learned in the dark days of 1914 to 1918. Bristow said in his discussion that the World War had taught three great lessons: (1) the value of the Thomas splint; (2) the need of segregation of fractures; and (3) the value of teamwork in fracture treatment. Each of these lessons is a stone in the arch of fracture treatment, but the theme of this discussion is the first: The value of the Thomas splint.

So far as the emergency treatment and transportation of fractures, particularly those of the femur, are concerned, war experience taught one fundamental lesson, namely, that simplicity of means and simplicity of apparatus are superior to more elaborate methods. By simplicity of means is meant that the emergency treatment of a compound fracture in war or in

civil life should consist of cleansing the external wound, control of serious hemorrhage by pressure or if necessary by tourniquet, and the application of a suitable sterile dressing to protect the area of injury, more elaborate procedures being delayed until the patient has been hospitalized. By simplicity of apparatus is meant utilizing for immediate and transportation splinting a form of fixation which can be applied without removal of clothing, by any individual of average intelligence, and which gives efficient immobilization of the fractured extremity.

It is an authenticated fact that the mortality rate from compound fractures of the femur in the British forces during the early years of the late War was extremely high. It has been generally stated to have been 65 per cent, but has been estimated as high as 80 per cent. It is further true that a large percentage of these deaths occurred en route to or at the casualty clearing station, that is, between the field of battle and the most advanced hospital unit at which the wounded received definitive hospital care. The immediate fatalities were the result of hemorrhage and shock, the later ones were caused by sepsis and gas infection.

An investigation of this appalling situation tragically brought home to those in authority the realization that most of the immediate catastrophes and most of the subsequent deaths were traceable to the added trauma the wounded suffered during transportation, owing to inadequate immobilization of the fractured extremity or extremities. That failure effectively to immobilize fractured bone ends before transportation results in soft tissue damage, excessive bleeding, and dissemination

\* Read before the American Orthopaedic Association, Buffalo, New York, June 5-8, 1939.

of infection was incontrovertibly established by this investigation.

During this period of the War, the Liston splint was used almost exclusively, a form of splinting for fractures of the femur which was difficult to apply efficiently and which supplied inadequate fixation for transportation. In 1916, largely through the persistent efforts of Sir Robert Jones, the Thomas traction splint was generally introduced into the British Army; this splint could be and was applied where the wounded man fell on the field of battle and was worn until he reached the base hospital, and usually throughout the entire course of his treatment. Almost at once, the picture changed, and the mortality rate of compound fractures of the femur in the British forces fell rapidly to 16 per cent and remained there. It should be emphasized that the only alteration made in treatment to bring about this change was substituting easily applied, immediate, adequate fixation in place of more complicated and inadequate splinting. This was attacking the problem at its source, and the results proved beyond any question of doubt the importance of immediate and continued immobilization in influencing the course of such fractures. This is what Bristow meant, in part at least, when he said that the War had proved the value of the Thomas splint.

The American Expeditionary Force, acting upon the advice of Goldthwaite, Allison, and Baer, who were familiar with the experience of the British, adapted traction arm and leg splints as the field equipment of its medical units. Army, corps, and division orthopedic consultants were entrusted with instructing the personnel of the army, corps, and divisional medical units in the application of these splints and were made responsible for seeing that splints were applied on the field of battle and before transportation was undertaken. On the whole, an excellent job was done, with the result that in the American Expeditionary Force the mortality rate of compound fractures of the femur was never

unduly high and that these fractures presented no greater problem than did compound fractures of any other bone.

While up to this point war has been stressed, one must keep in mind that the problems of treatment of fracture of the shaft of the femur, both preventive and curative, are virtually the same for the civilian at home as for the soldier in the field, and differ only in the urgency of appeal to our sentiments and to our best efforts. The widespread mechanization of our country in the past two decades has changed in innumerable ways the conditions under which we live; among the changes has been an increased liability to injury, not only as an occupational risk but in the routine of daily life. The accident toll in the United States for 1937 was 106,000 fatalities, 9,900,000 injuries, and 375,000 permanently disabled. When we realize that in 1937, the total accidental injury list was two and one-half times the total number of American troops engaged in the World War, and that the number of deaths in the American forces was but 50,510, it seems quite clear that at the present rate, our yearly accidental casualty list causes our casualties of the World War to shrink into insignificance. This suggests that measures of proved worth in the management of wartime injuries have a far greater field of application in civilian life than has been offered in any war fought up to the present time. This is particularly true of fractures—of which there are from one-half to one million annually. One table, for four states, including only occupational injuries, lists fractures as comprising 17.7 per cent of all injuries. In highway accidents, the percentage is almost certainly higher.

Predicated upon wartime experience, the statement can be made that effective emergency treatment and transportation splinting of fractures in civilian life will, in many instances, check serious hemorrhage, minimize the danger of shock, lessen the dissemination of infection, and influence to an important extent the period of incapac-

ity incident to recovery and the degree of permanent disability. Stated in another way, proper first aid treatment of fractures plays an important and even vital rôle in determining the course and result in practically every serious fracture. Furthermore, it may be stated that Thomas traction splints have been found to be the most efficient type of splint for emergency use because of the simplicity of their application and their effectiveness in providing immobilization.

Have these lessons learned in war time been applied to civilian life? The answer to this question is both yes and no. Earnest and result-producing efforts are being made to drive home these lessons, but their importance as life-saving measures and as a means of favorably influencing the subsequent course of healing have not received the general acceptance necessary if our civilian casualties are to be given the full benefit of the information which is available.

The Fracture Committee of the American College of Surgeons, working through its regional and state committees, has been actively attempting to arouse a nation-wide recognition of the importance of adequate splinting of fractures at the scene of an accident and before the injured person is transported. This Committee has constantly urged that the principle of splinting before transportation applies not only to patients who must be transported for long distances but also to those whose journey to the hospital is short. Damage may be inflicted by rough and unnecessary handling in moving a patient as well as by repeated and prolonged trauma. The efforts of this Committee are producing results in some sections of our country. City ambulances, the fire and police departments in many of our large cities, and the first aid crews of a considerable number of large industrial plants are equipped and trained in proper first aid treatment and splinting of fractures. The chief surgeons of our railways have responded splendidly, and most railroads provide traction splints at

strategic points for transportation. The important field of caring for highway accidents has been taken over by the American Red Cross. They have established 2,652 Fixed Highway Emergency First Aid Stations and 2,363 Mobile Units over the United States. These stations are supplied with half-ring leg and arm traction splints in the application of which the personnel is trained. The central office of the American Red Cross reports that it is receiving word from physicians and hospitals of excellent results in the handling of fractures by these units. The tremendous toll in death, suffering, and permanent disability which highway accidents are taking all over our country raises this First Aid Service to an important position, and the medical profession is obligated to lend its support to the Red Cross in establishing these units and training personnel.

Progress is being slowly made toward providing adequate care for accidental injuries occurring among civilians. Sentiment has not, unfortunately, up to the present time, stirred the nation and the profession to effort on behalf of civilians comparable to that demonstrated toward soldiers in the field. There can be no let-up in our efforts until traction splints and a trained personnel are available always—in the factories, at the pit mouth, on all railways, and in every first aid outfit.

During the past four years, military operations of greater or less magnitude have been occurring in Ethiopia, Spain, China, and Europe; these provide opportunity for further study of methods of treatment of fractures due to bullets and projectiles of various kinds. A rather extensive perusal of the writings of those having had actual experience on these various fronts reveals no evidence of the development of any form of emergency treatment or any form of transportation splinting for fractures which is an improvement on that used in the World War. In other words, the administration of anti-tetanic and gas sera, cleansing of the external wound, control of hemorrhage,

the application of a suitable sterile dressing, and efficient immobilization by traction splint before and during transportation still constitute the best emergency treatment for fractures of the femur in war, and it might be added, in the accidents of civilian life.

This statement applies only to the *emergency phase* of fracture treatment which should be considered to include only the measures taken from the time that the injury occurs until the injured individual reaches a medical unit or hospital where more elaborate procedures may be safely carried out. If, however, this emergency treatment is to be extended to include the measures which aim to correct soft part damage and improve alignment, then there is important information to be gained by study of the experiences of the World War and these more recent conflicts. For example, the question of debridement and conversion of a compound fracture into a

simple fracture, the advisability of applying the principles of the Orr treatment for compound fractures at the most advanced hospital units, and the superiority of traction over operative forms of internal fixation in war surgery offer very interesting subjects for discussion. These aspects of fracture management, however, seem to lie beyond the field of emergency treatment and will no doubt be covered by other contributors to this Symposium.

#### CONCLUSION

Emergency treatment in fracture of the shaft of the femur, simple or compound, in civil life or in war, should consist of cleansing the external wound, controlling hemorrhage, protecting any open wound by a suitable sterile dressing, and immobilizing the limb by traction splint applied before the injured person is moved or transported.



# THE TREATMENT OF FRACTURES OF THE SHAFT OF THE FEMUR IN CHILDREN

A. B. LEMESURIER, M.D.

Hospital for Sick Children

TORONTO, ONTARIO

THE treatment of fractures of the femur in children is much simpler than it is in adults. The results on the whole are more satisfactory, and the period of disability is shorter. In children, union takes place more rapidly, delayed union is rare, and nonunion is practically unknown unless some gross pathologic change is present. The stiffness of the joints passes off soon after use of the limb is allowed, and the other changes that take place in the limb, stiffness and atrophy of the muscles, and circulatory changes, soon disappear.

The great majority of patients admitted to the Hospital for Sick Children, Toronto, with fractures of the femur, are over the age of 2 years, and the fracture is in the middle third of the shaft. Practically all these patients are treated by extension in a Thomas splint. There is nothing new about the way in which we use the Thomas splint, but for some reason this method is not in general use. (Fig. 1.) The end of the Thomas splint is tied on the top of the end rail of the bed so that it cannot rotate and the extension is obtained by having the patient lie on an inclined Bradford frame. There is much less friction on a Bradford frame and more extension can be obtained with the same amount of tilt than when the patient is lying on an ordinary mattress with fracture boards beneath it. Only one pillow is allowed, and with small children tiedowns are necessary to prevent them from sitting up. The inclination of the frame should at first be about one in three, that is if the frame is 6 feet long its foot end should be about 2 feet higher than its head end, and the amount of extension can be increased or decreased by altering this inclination. Beyond the fixation of the end of the splint to the rail of the bed, the splint

is not supported or suspended in any way. There is no point, in a child, of holding the foot up at a right angle. A foot piece is usually put on, but it is used only to keep the pressure of the bed clothes off the foot.

This method of supporting the Thomas splint and applying extension without undue pressure on the ring is very simple and very efficient. There is a tendency nowadays to make the treatment of fractures much too complicated. The addition of several counterweights does little real good. The more elaborate any apparatus is, the more likely it is to go wrong. There is very little about this method that can go wrong. The extension can be made adequate and is constantly maintained, and the child is allowed as much movement as is good for his fracture or is necessary for nursing purposes. These children stand the tipped-up position extremely well, but the position is not used when there is any severe intracranial injury.

The putting up of the fracture in this way is by no means the whole of the treatment. There are several things to be considered, and perhaps the most important is that certain things should be done at the proper time. The sooner after the injury that the patient is put up in an apparatus like this, the less pain he has, the less deformity and less injury to the soft tissues there is, and the simpler it is to correct any deformity that is present. Every child admitted to the Hospital for Sick Children, suffering from any serious injury, is immediately put on a Bradford frame in the Admitting Department and any further shifting is avoided. If the femur is broken, no matter at what level, it is put up in a Thomas splint on an inclined frame as soon as possible. In most cases the diagnosis of

the fracture is obvious, and in most cases the fracture is put up in a splint before any x-ray is taken. Unless the fracture is not

functional result. The reasonable thing to do is to adopt some standard of position that can be considered as satisfactory, to

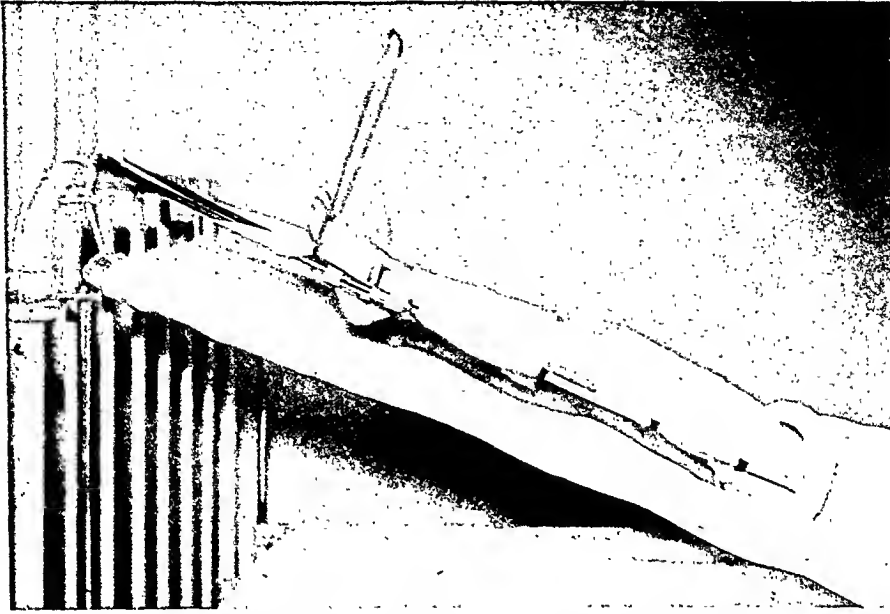


FIG. 1. Thomas splint applied. The patient lies on an inclined Bradford frame, with the end of the splint tied to the end of the bed.

even suspected, no child is allowed to lie overnight without fixation and extension. No anesthetic is used in applying the Thomas splint, but some sedative is usually given, if this has not been done before admission. No real attempt is made to reduce the deformity when the splint is being put on, but this takes place gradually during the next couple of days under extension and in comparative comfort.

The next step is to get the fragments in a position that can be considered satisfactory. There is some difference of opinion as to what constitutes a satisfactory position. It is well known that, in children, a great deal of improvement in both length and alignment may take place with growth, but the hope that all deformities in children will correct themselves is no excuse for leaving a bad deformity that, at the time, can be corrected by fairly simple means. On the other hand, it is unwise and often harmful to submit the child to frequent manipulations in order to correct some minor fault in position that is shown in the x-ray but is not sufficient to cause any delay in union or to affect in any way the

make every attempt to obtain a position within the limits of this standard, and once such a position is obtained, to maintain it, with as little disturbance as possible, until union takes place. The standard we aim at is to have the fragments in contact, in oblique fractures to have fractured surface against fractured surface, to have the bone pulled out to full length, and to have the general line of the two fragments parallel, with no obvious varus or valgus deformity and no recurvation. This standard may not seem particularly high and does not necessarily mean a perfect x-ray picture but, with it, in children we can expect union and a perfect functional result.

When the child is first put up in the splint he is left in the same position with a fairly strong extension for two or three days and then an x-ray is taken. This is often the first x-ray taken of the fracture. If the position is satisfactory no further change is necessary, but if it is not satisfactory, every attempt is made to improve it before the fragments have become at all fixed in a faulty position. It is a comparatively simple matter to alter the relative



position of the fragments during the first few days, but at the end of the first week this is difficult, and after that it becomes progres-

sive. The displacement can be corrected by tightening the sling under it, and lateral displacement can be improved by pulling the fragments

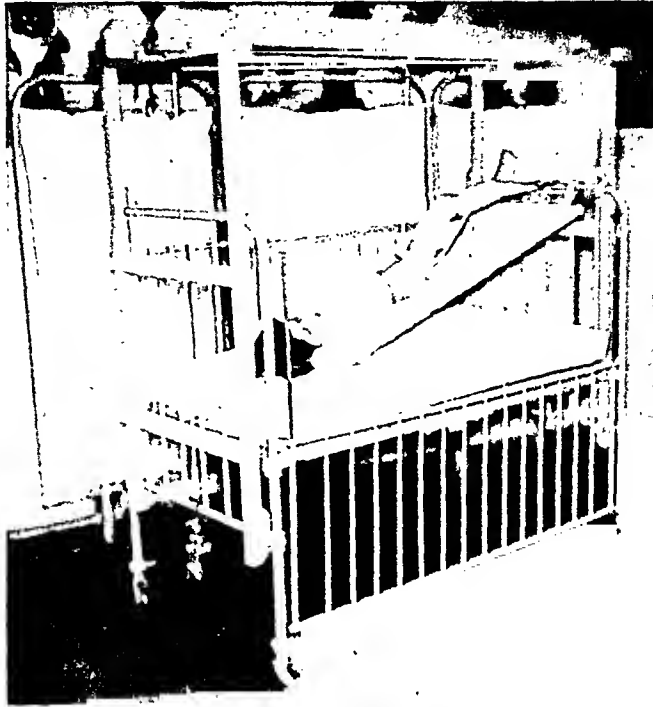


FIG. 2. Method of using Hodgen's splint for correction of backward displacement of lower fragment in high fractures.

sively more difficult. Any deformity that is not discovered until after two or three weeks is very difficult to correct, and any attempt at correction at this stage delays union.

After two or three days, under fairly strong extension, most fractures of the shaft of the femur have come to lie in satisfactory position. In fractures of the upper and lower thirds a bad deformity that is still present at this stage cannot be corrected satisfactorily by the same form of treatment, and the methods used in the treatment of these cases will be discussed later. In fractures of the middle third (these include the vast majority of the fractures of the shaft) any deformity that is still present is usually a minor one and can be improved by fairly simple means. There is no difficulty in children at this stage in pulling the bone out to length by increasing the extension. The frequent backward displacement of the lower frag-

ment can be corrected by tightening the sling under it, and lateral displacement can be improved by pulling the fragments towards either bar of the splint. All this altering in position should be done in the first week, and at the end of the first week we should have x-ray evidence that the position is satisfactory. With some faulty positions it is occasionally wise to manipulate the fracture under an anesthetic at an early stage. Sometimes it is wise to do an open operation with direct fixation of the fragments.

It is very difficult deliberately to change the position of the fracture after the first week, and if it is in good position at that time it is not likely to get out of position later, provided that it is kept adequately splinted. The strong extension is no longer necessary and can be gradually reduced, but a fair amount of extension should be kept up as long as the Thomas splint is worn. The splint needs a good deal of attention—keeping the slings in place and tight enough, and keeping the adhesive extension bandaged closely to the skin.

After four weeks, the union in children is fairly firm. It will still bend, if allowed to, but there is no tendency for the fragments

splint to the plaster spica is to shorten the stay in hospital. Four weeks after the injury, then, the Thomas splint is removed

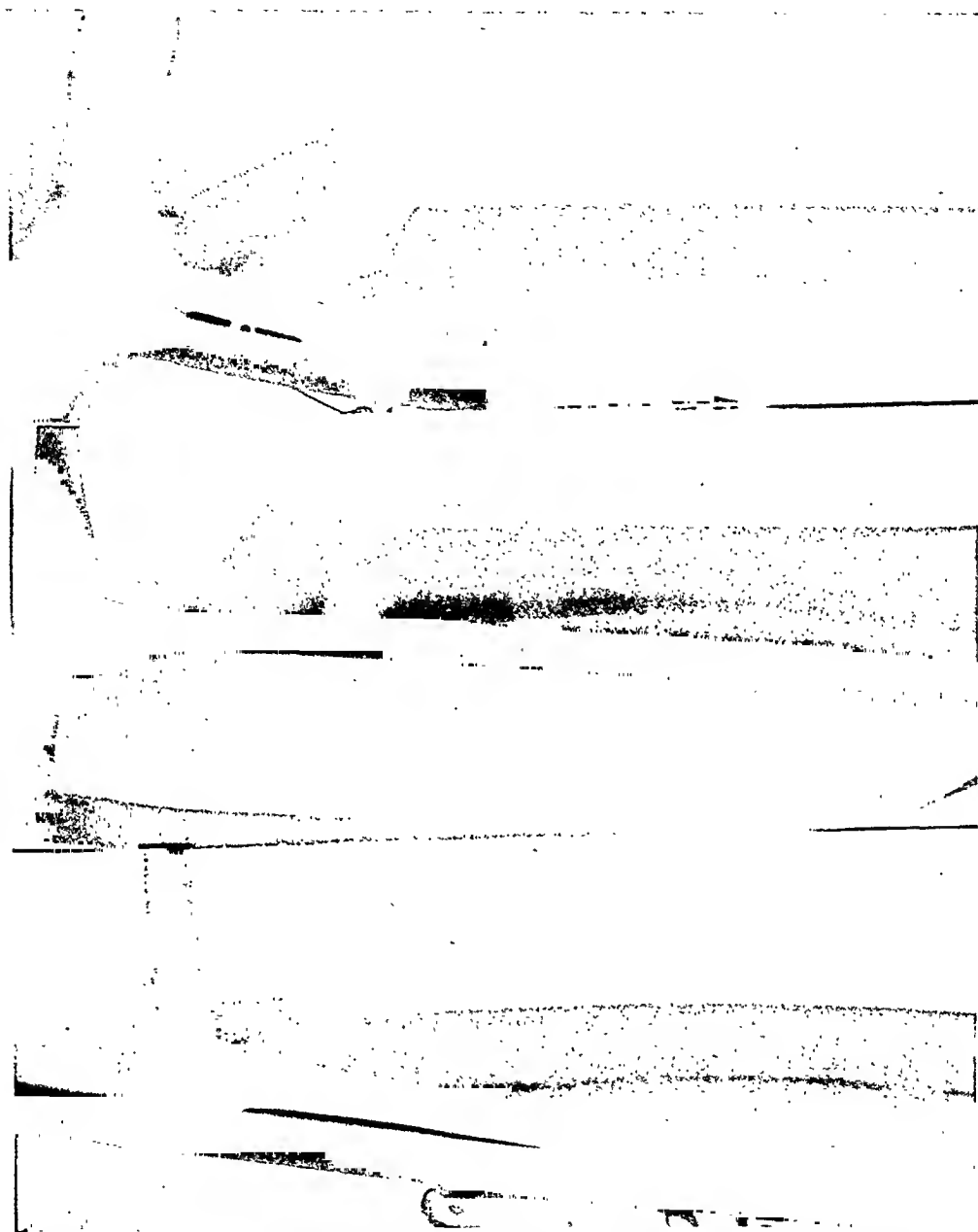


FIG. 3. X-rays showing stages of correction of backward displacement of lower fragment by means of Hodgen's splint.

to override or to become shifted. Extension is no longer necessary, and all that is needed is to keep the bone from bending at the fracture. This can be done efficiently by means of a plaster spica, which can be applied at this stage without any pain. The plaster spica needs much less attention than the Thomas splint and in it the child can be looked after quite well at home. The only reason for changing from the Thomas

and the plaster spica applied. The child is sent home in this, to stay in bed there, and to report back to the out-patient department when the plaster is to be removed—about ten weeks after the injury. In young children with long oblique fractures, this time is shortened, but in older children with transverse fractures, it is lengthened. This average time of ten weeks errs somewhat on the side of safety. During the last

three years only one refracture has occurred after walking was started, but this was produced by an injury severe enough to break a normal bone.

After the removal of the plaster the child is kept in bed for a further week and encouraged to kick the limb about. He then starts to get up. After a further month he is usually able to walk without any limp, with fair movement at the knee, and the muscle atrophy has partly disappeared.

Fractures of the upper third of the shaft seldom cause much trouble. Most of them, after two or three days in a Thomas splint with extension, are found to be in satisfactory position and no change is made. Occasionally it is found that the upper fragment is flexed forward considerably and the lower fragment is displaced backward with sometimes a space between the two fragments. By vertical extension the two fragments can be made parallel, but the backward displacement cannot be corrected and, in a Thomas splint, the tightening of the sling under the lower fragment does little to correct the displacement. For these cases we use a form of Hodgen's splint (Fig. 2) which is really a Thomas splint with the back half of the ring cut off. The longitudinal extension is obtained in the same way as it is with the Thomas splint, but the top sling is placed under the upper end of the lower fragment, and the top end of the splint, and with it the sling and fragment are pulled strongly in a forward direction by a weight over a pulley. This brings the two fragments into contact (Fig. 3), but with a considerable forward angulation. This position is maintained until the fragments are more or less fixed together by a union that is still flexible, that is for about two and a half weeks. The forward pull is then lessened and the two fragments allowed to fall back together and the forward angulation is straightened.

In lower third fractures, the position is found satisfactory in most cases. Sometimes, however, there is a bad posterior angulation of the lower fragment and this is difficult to correct by the Thomas splint,

even by bending it at the knee. It is well known that this displacement is usually easily corrected by some form of skeletal traction, and we use this method in children, but even when skeletal traction is used, it is much easier to get a satisfactory position if it is applied during the first few days.

With small infants the Thomas splint is not satisfactory. In these infants the vertical suspension of both legs by the Bryant method provides adequate extension, is clean and comfortable, and while the position is sometimes far from perfect, the functional result is usually excellent. A short Bradford frame (Fig. 4) is used to which are fixed two metal uprights with a crossbar at the top, and to this the legs are suspended by adhesive extension. I think that it is better to fasten the extensions to this crossbar with the buttocks hanging free, than it is to suspend them by any weight and pulley. The older the child becomes, the more difficult it is to obtain adequate extension by this method unless only one limb is suspended, or unless a counterweight is used and the pelvis fixed by a tiedown as suggested by Conwell.<sup>1</sup> We have found it better and now make it routine practice to treat every child over the age of 2 years with a Thomas splint. The Thomas splint is efficient and comfortable and can be kept reasonably clean with these small children.

During the last three hospital years, that is between October 1, 1935 and September 30, 1938, there have been admitted to the Sisk Children's Hospital 212 patients with 218 recent fractures of the shaft of the femur. Of these patients, two died, both from extensive intracranial injuries. Several had other injuries, some of them severe, but none of them had a severe injury of a large artery or nerve in the damaged thigh. Only two of the fractures were compound and in both the wounds healed up without any bone infection.

Of the 216 fractures in children that lived, fourteen were in children under the age of 2 years. These were all treated by

vertical suspension. They all united within a reasonable time and, while the x-ray appearance was sometimes far from perfect,

injured leg within three months of the injury. There was no definite delayed union and no nonunion. In no case was

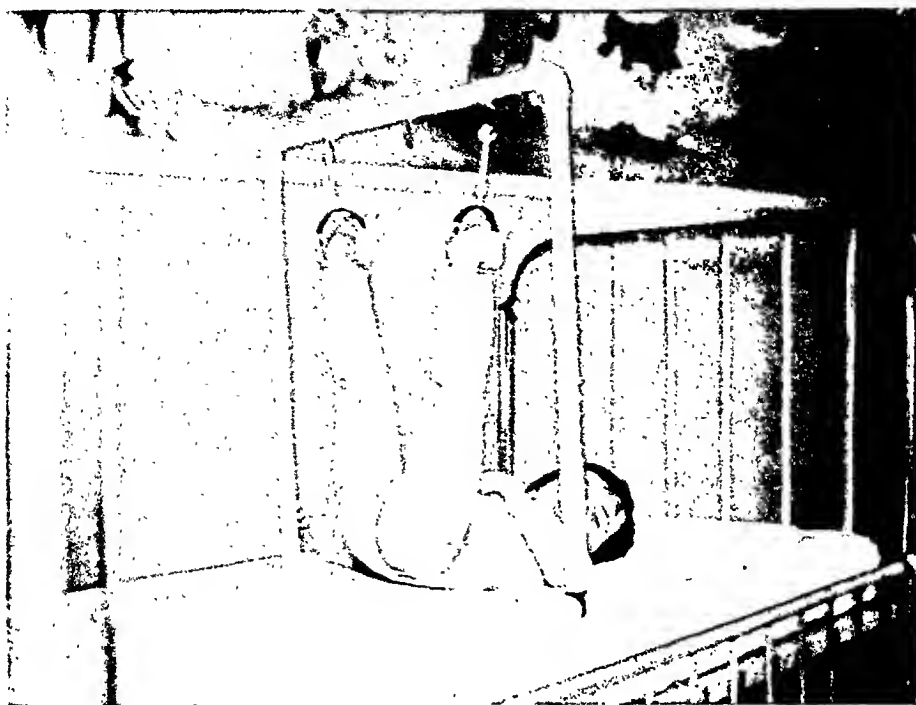


FIG. 4. Vertical suspension for treatment of fractures of the femur in infants.

the functional result was apparently good in every case.

Of the 202 fractures in children over the age of 2 years, 162 were in the middle third, twenty-five in the upper third; and fifteen in the lower third. Of the 162 middle third fractures 148 were treated in a Thomas splint with adhesive extension, seven were treated in a Thomas splint with a Kirschner wire extension, three had an open operation done and four were treated in a simple plaster spica with no extension, because the fracture was incomplete and without displacement. Of the twenty-five upper third fractures, the position in nineteen was considered satisfactory in the Thomas splint, and this treatment was continued, but six were transferred to a Hodgen's splint to correct a backward displacement of the lower fragment. Of the fifteen lower third fractures, six had Kirschner wires inserted.

All these fractures united. Union took place within a reasonable time and, unless there was some complication elsewhere, all the children were taking weight on the

there any bending at the fracture on weight-bearing, although in one case the fracture recurred as the result of a fairly severe injury.

In only one case was there a deformity that was considered sufficiently severe to require correction. In this case the bone became rather badly bent while it was still in plaster, because the child, contrary to instructions, was allowed to walk on it. In all the other patients the position was considered satisfactory, and in none of them was there enough difference in the length of the limbs to require a lift under the shoe.

The knee stiffness varied in duration. Very often there was a full range of movement two weeks after the removal of the plaster, but sometimes some limitation of movement persisted for as long as two months. In this series there was only one case of prolonged limitation of movement, and this occurred in a fracture that had been plated and had become infected.

With this method of treatment, accidents sometimes happen. In one case when

the patient was operated on and plated, infection took place, but the wound has now been healed for some time. In one case a Volkmann's paralysis occurred, probably due to a bandage that was too tight. It was followed by a fibrosis and shortening of the calf muscles and a tendon lengthening was later done. Anesthesia has now disappeared and the patient is able to walk without a limp, and has fair power in his calf. Two cases of peroneal palsy appeared, caused by pressure of a sling in the region of the neck of the fibula. Both these recovered completely in about six weeks time. These four mishaps were, in this series of 216 fractures, the only ones of any severity that could be blamed on the treatment.

#### CONCLUSIONS

I have tried to impress the need of getting these fractures into splints with extension as soon as possible after the injury, and of getting the fragments in satisfactory position during the first week, before they have become so fixed that they

are difficult to shift. A small number of fractures of the shaft of the femur require special treatment, and the sooner the need for this is discovered, the better the results will be. The majority of these fractures, however, can be satisfactorily treated with the Thomas splint in the tipped-up position. This method of treatment has been in use at the Hospital for Sick Children for the last twenty years, with practically no change. It is extremely simple. It is quite comfortable to the patient throughout its whole course, it causes very few accidents, and with extremely few exceptions the results are entirely satisfactory. With us the method has been so satisfactory that, beyond the fact that a hospital bed is occupied for about four weeks, a fracture of the femur causes less worry and trouble than many other fractures.

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# OVERGROWTH OF THE FEMORAL SHAFT FOLLOWING FRACTURE IN CHILDREN

ALEXANDER P. AITKEN, M.D.

BOSTON, MASSACHUSETTS

SEVERAL cases of compensatory overgrowth and some cases of lengthening following fracture have been reported by H. Earle Conwell, W. H. Cole and by Burdick and Sirius.

At the Boston City Hospital we have made a study of the end results in seventy-one cases of fracture of the femoral shaft in children under 16 years of age. These cases have been followed from three months to eight years. In this group we have used a film 4 feet long with a special cassette, the child standing erect on a level lead platform, the tube placed at a distance of 7 feet.

The cases may be divided into two age groups: one 13 years of age or older, the other 12 years of age or younger.

The older group contains six cases, and the average duration of time since fracture is five years. All fractures either were anatomically reduced or had lateral displacement without shortening. At the present time in five cases an average shortening of 1 cm. is present. The remaining patient, 13 years of age at the time of fracture, shows 0.6 cm. lengthening. The epiphyses are closed so the lengthening in this case is permanent.

In the group 12 years of age or younger there have been sixty-five cases. This group differs markedly from the older classification, in that all but one show lengthening of the femur from the position on discharge. In nine cases anatomic reduction was obtained. In one there is now no difference in the length of the femora, while in the remaining eight cases the fractured femur averages 1.1 cm. longer, an amount sufficient to tilt the pelvis and cause a slight scoliosis. Seven patients were discharged with lateral displacement but no shorten-

ing. These also show lengthening, the average being 1.1 cm. One patient, overpulled by 0.7 cm., is now 1.7 cm. longer.

Eight open reductions were performed. Anatomic position was maintained in four cases and these femora are now 1 cm. longer than the sound limbs. In four cases bowing occurred despite the plate, shortening the femur an average of 0.8 cm. These cases now average 0.8 cm. lengthening, an average overgrowth of 1.6 cm. from the position on discharge.

Thirty-eight patients were discharged with complete displacement and overriding. In twenty-one cases the fractured femur is now actually longer than the sound one. In nine of these cases, the average shortening was 1.2 cm. and the average lengthening is now 0.4 cm., an overgrowth from the position on discharge of 1.6 cm. In twelve patients discharged with shortening of 0.6 cm., there is now an average lengthening of 0.7 cm., an overgrowth from the position on discharge of 1.3 cm. In seventeen cases there is still some shortening. The average shortening on discharge in eleven cases was 1.3 cm. and is still 0.5 cm. In six cases the average shortening was 0.6 cm. and is now 0.2 cm.

From the above figures it can be seen that those cases showing the most shortening on discharge also showed the most overgrowth. Apparently the greater the displacement, the larger the callus and the longer it persists. Hence there is a longer period of periosteal hyperemia and epiphyseal stimulation.

Overgrowth of 1 cm. occurred in two cases of pathologic fractures through bone cysts.

There were nine cases of fracture within the past year. In two cases of under

six months' duration, the overgrowth amounted to 0.3 cm. In seven cases of six months' to one year's duration, the average overgrowth was 1 cm. Overgrowth thus occurs while the callus is still present, i.e., during the first year.

The same relative overgrowth occurred in the upper, middle or lower third, regardless of whether the fracture was spiral, transverse or comminuted. Although this overgrowth has been described as compensatory, the fact that anatomic reductions show the same degree of overgrowth leads us to believe that it is not a true compensation but rather due to epiphyseal stimulation resulting from periosteal hyperemia. Others believe that any overgrowth is balanced by the time of epiphyseal closure. This may be true. However, in six cases in which epiphyseal fusion has occurred, the femora are still 1 cm. longer. In three other patients, now 17 years of age and in whom fusion is about to occur, the average overgrowth is 1.3 cm. The average time since fracture is seven years. In these nine cases at least we believe the lengthening is permanent.

In presenting this paper we are well aware that our figures are only relatively accurate. The original roentgenograms were not taken at a distance of 7 feet; measurements of such plates cannot be accurate, and some distortion is invariably present. We are also aware of the fact that it is not uncommon to find normal children with one extremity longer than the other without a history of bone infection or trauma. The consistent finding of lengthening on the fractured side we do believe is significant of overgrowth due directly to trauma.

#### SUMMARY

In fractures of the femoral shaft in children under 13 years of age, we can expect an average overgrowth of 1 cm. from the position on discharge, regardless of method of treatment. In anatomic reductions a tilted pelvis and a slight scoliosis may be produced.

If a child can be compensated for a leg that is  $\frac{1}{2}$  inch short, why should not similar compensation be given for one that is  $\frac{1}{2}$  inch long as a result of fracture?



# TREATMENT OF FRACTURES OF THE SHAFT OF THE FEMUR BY SKELETAL TRACTION AND THOMAS SPLINT\*

GEORGE W. VAN GORDER, M.D.

BOSTON, MASSACHUSETTS

**A**N important milestone was passed in the history of fracture treatment, when, during the Great War, skeletal traction was introduced and established as the simplest and most effective method of treating fractures of the femur. Its superiority over other methods of traction was early recognized, and there is no further need of proving its value. Since its advent, all forms of skin traction have been used less and less and have come to be considered inadequate, or should be so considered, for the proper care of fractures of the shaft of the femur in adults.

This report concerns all fractures of the femur treated by skeletal traction in the Massachusetts General Hospital during the past fifteen years. The patients were treated by different surgeons on three separate surgical services and, while a Thomas splint and skeletal traction were universally employed, the minor details of treatment varied with the individual surgeon. In other words, this report represents the combined experience of a number of surgeons. If the end results appear to be satisfactory under such a régime, it is only fair to assume that, with a centralized organization or control by a real fracture service, the results would be far better.

The total number of patients treated by skeletal traction with Thomas splints was fifty-eight, of whom four were under 10 years of age and two over 70. The sex ratio showed forty-four males and fourteen females. Fifty-one of the fractures were simple and seven were compound.

In eleven patients adhesive plaster skin traction was first used and found to be inadequate in every instance. Various types of skeletal traction were employed: ice

tongs in thirty-six cases; Kirschner wires in eighteen; and Steinmann pins in four cases. Needless to say, since the introduction of the Kirschner wire, the ice tongs and Steinmann pins have been discarded and all skeletal traction now used is of the Kirschner wire type.

I need not here describe the technique of introduction of a Kirschner wire, although, in certain cases of supracondylar fracture, the proper placement of the wire is of paramount importance. In those instances where the supracondylar fracture lies close to the knee joint, it has been our custom in the past to insert the Kirschner wire into the crest of the tibia just below the tibial tubercle and to pull through the slightly flexed knee joint in a line as nearly parallel to the plane of the tibia as possible. In this manner, the traction force is transmitted through the joint with the least amount of strain on its ligaments. A common fault and a serious one is to flex the knee too much, which vitiates the pulling force if transmitted along the line of the tibia, or causes a dangerous shearing force on the joint if transmitted in the line of the femur.

Because of this danger and the difficulties of controlling the distal fragment in many cases, we have arrived at the belief that open operation with internal fixation is the treatment of choice in this type of fracture. This avoids long fixation of the knee or strain upon it, restores bone length and alignment, and gives an earlier and far better functional result.

In intertrochanteric fractures with complete separation of the fragments, where the femoral shaft rotates externally and internal rotation is desired, again the proper placement of the Kirschner wire will

\*From the Fracture Clinic, Massachusetts General Hospital.



readily maintain the internal rotation while traction is being applied.

In the fracture apparatus commonly

When more than the normal amount of traction is required, as in cases of over-riding with early callus formation present,

Supracondylar Fractures of the Femur  
Treated by skeletal traction

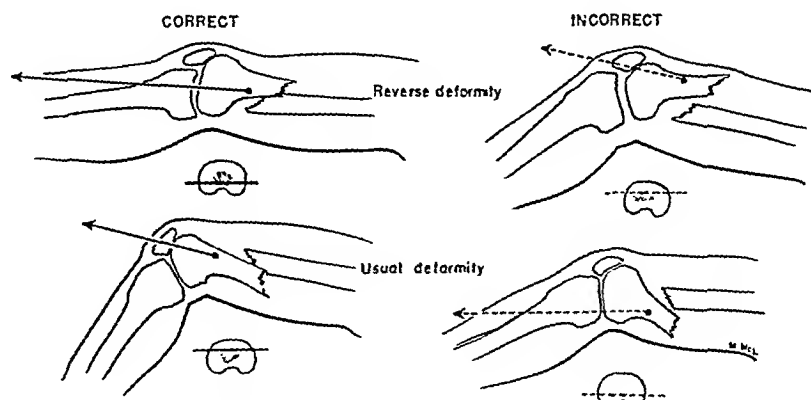
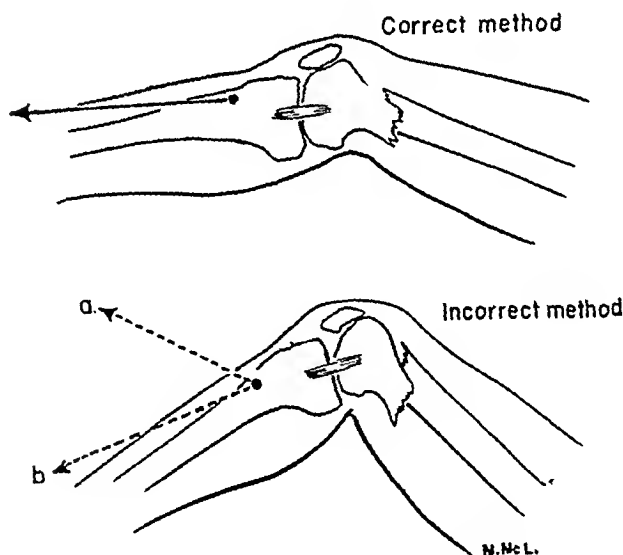


FIG. 1. Correct and incorrect methods of traction.

Supracondylar Fractures of the Femur  
Treated by skeletal traction  
From the crest of the Tibia



- a.-Produces strain on ligament of knee
- b.-Inefficient for bone length

FIG. 2. Correct and incorrect methods of traction.

employed in this series of cases the Thomas splint simply suspends the leg while the traction force is exerted against the patient's body weight. A Pearson attachment is applied to the Thomas splint in all instances to allow flexion and extension of the knee, while traction continues undisturbed.

the pulling force is exerted against the patient's ischial tuberosity and the lower end of the Thomas splint is fixed to the bed or Balkan frame.

In compound fractures with extensive sepsis where pus has a tendency to gravitate along muscle and fascial planes, it is sometimes necessary to prevent the spread-

ing of the infection by changing the position or plane of the fractured leg. The usual position of the femur while under traction treatment requires the knee joint to be at a higher level than the hip, which means that infection, if not recognized or uncontrolled, will gravitate toward the dependent gluteal area. To offset this tendency and to control the optimum level for the femur, it is often necessary to raise the head of the bed until the femur is horizontal or the knee joint lower than the hip. At the same time, a support should be placed in the foot of the bed, against which the patient can rest his free unsplinted foot. Otherwise, his body weight plus the traction force might result in excessive pressure against the Thomas ring.

The complications of skeletal traction are not numerous, but can be both embarrassing and serious. In this series of fractures, all the complications, except one, occurred with ice tongs. In four cases, the ice tongs slipped out of position; in three cases, patients were uncoöperative and removed the tongs; in two instances, the tips of the ice tongs broke off; and in one patient, an infection of the bone resulted from their use. The only complication encountered with Kirschner wires was a breaking of the wire in one case.

The danger of overpulling with the use of skeletal traction should be mentioned in passing, since, as is well known, it predisposes to nonunion. One patient in this series had to undergo later operation on this account and another had delayed union for the same reason.

In fourteen cases of the total of 58, skeletal traction was given up during the course of treatment. (Table 1.)

TABLE 1  
REASONS FOR ABANDONING SKELETAL TRACTION

	No. of Cases
Unsuccessful reduction.....	7
Nonunion.....	3
Compound fracture—fulminating infection—amputation.....	1
Delirium tremens—kept removing ice tongs.....	1
Operator's choice.....	1
Death.....	1
Total.....	14

Reduction of the fracture by skeletal traction was unsuccessful in seven cases. In only one of these was definite interposi-

Intertrochanteric Fracture  
With external rotation of shaft  
Treated by skeletal traction

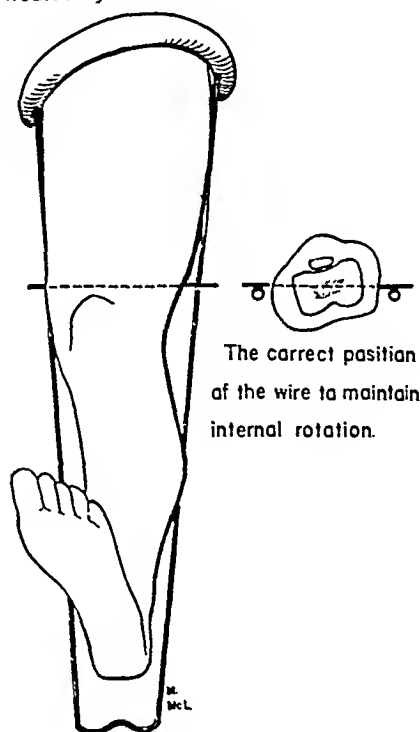


FIG. 3.

tion of muscle found between the bone fragments at operation. In the remaining six, one patient with a transverse mid and lower third fracture failed to obtain satisfactory reduction with 25 pounds of ice tong traction and had an open reduction with plating. Another with a spiral lower third fracture was treated by adhesive plaster traction for three days, ice tong traction for eight days, and then, because of unsatisfactory position, had an open reduction with Parham band fixation. A third patient, 9 years of age, with a transverse mid third fracture, had two unsuccessful attempts at closed reduction, followed by traction with a Steinmann pin in the os calcis. The position of the bone fragments was considered unsatisfactory and the femur was plated. A fourth patient, an imbecile, with a comminuted mid and lower third fracture had Steinmann pin traction through the tibial crest without success; full length was obtained, but the

lateral displacement could not be overcome and open reduction with plating was performed. The fifth and sixth patients had

Satisfactory reduction was not obtained and the fractures were accordingly plated. There were three cases of nonunion in

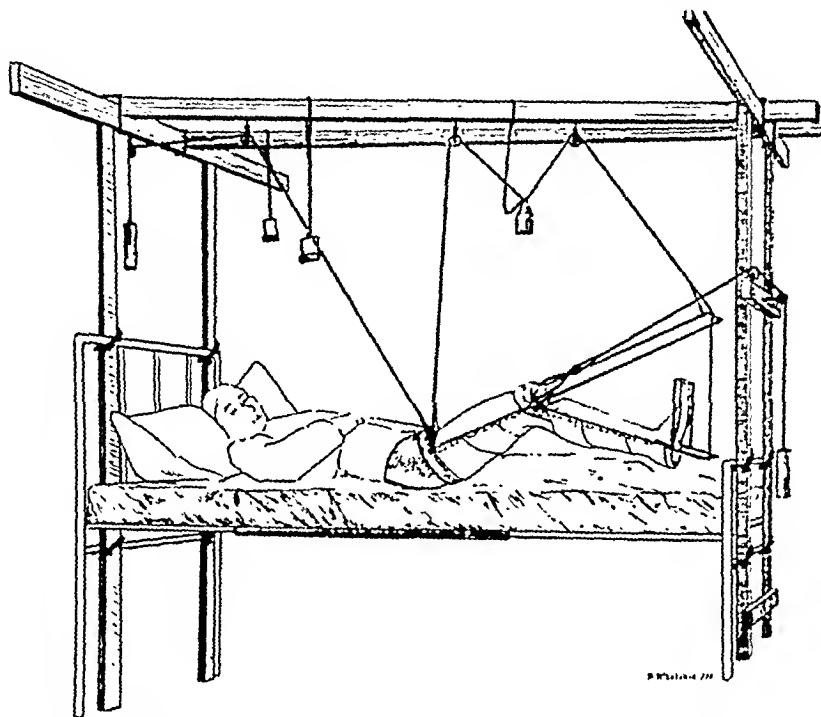


FIG. 4. Method of skeletal traction commonly used in this series of cases.

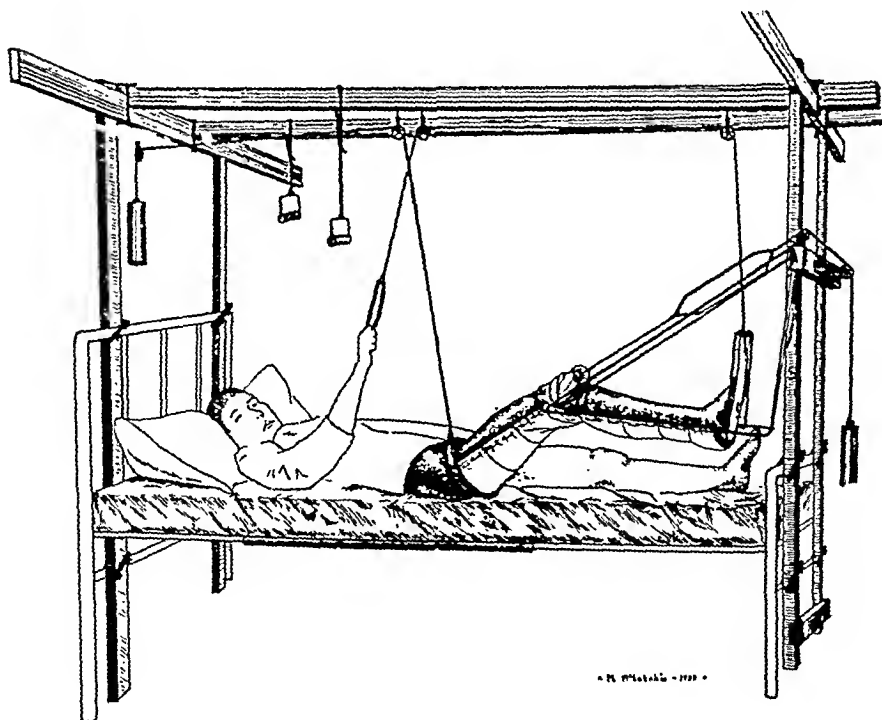


FIG. 5. Method used when maximum traction is required.

transverse mid third fractures which were treated with Kirschner wire traction.

this series, one of which could be definitely attributed to too much traction or overpull

with ice tongs. This patient later had bone grafting done.

In another patient, the Kirschner wire

The twelfth patient had delirium tremens at the time of his fracture and kept removing his ice tongs and suspension appa-

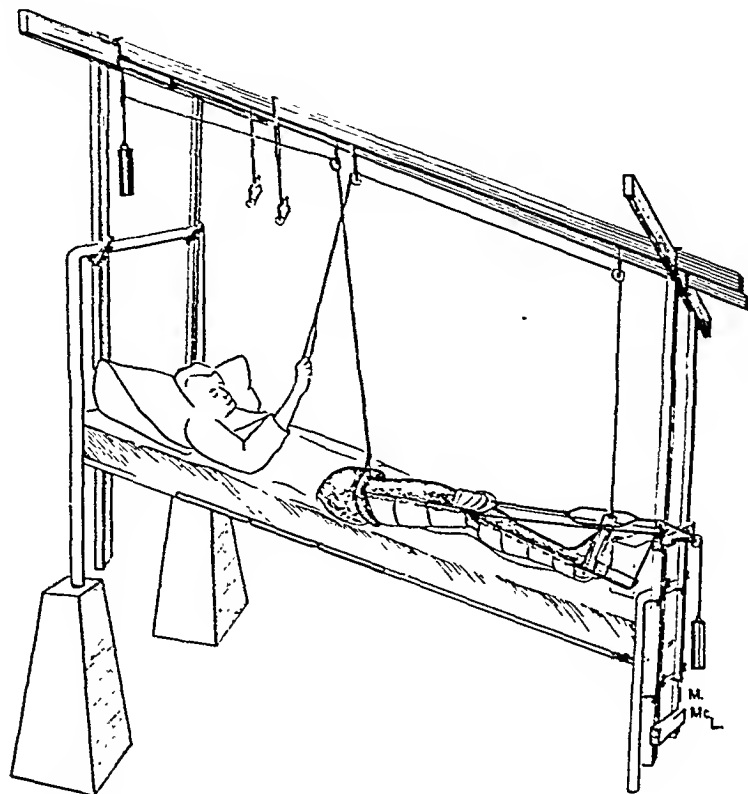


FIG. 6. Method of treatment employed in compound fractures of the femur with extensive repairs.

broke one month after insertion and, since the bone fragments were in good position, the leg was placed in a plaster spica. Unfortunately, the patient did not return to the follow-up clinic for several months, when it was found that the femur had bowed laterally and there was nonunion.

Another patient, 67 years of age, with severe diabetes had already had bilateral amputations of both lower legs for diabetic gangrene before fracturing the mid third of his right femur. Normal healing of the fracture did not take place and nonunion resulted, for which he had a mid-thigh amputation.

Still another of the fourteen unsuccessful skeletal traction cases was a patient who sustained a severe *compound supracondylar* fracture that was treated by Kirschner wire traction at the tibial tubercle. The infection in this case could not be controlled and became so fulminating that a guillotine amputation was necessary as a life saving procedure.

ratus. Open reduction with bone plating was finally resorted to.

In the thirteenth case a simple transverse mid third fracture was treated by Kirschner wire skeletal traction for three weeks. At the end of that period, the patient's surgeon decided to do an open reduction. (Reason not stated.) From the appearance of the x-rays it would not be fair to assume that skeletal traction had failed, so the only reason given for discontinuing the skeletal traction is "operator's choice."

The last case was a patient who had multiple compound fractures with extreme shock. He had three transfusions and rallied from his shock so that a Kirschner wire was inserted into his os calcis. Four days later, however, pneumonia set in and resulted in death.

*Period of Hospitalization.* In forty-five cases the time in the hospital is recorded. Six had a protracted stay of from four to six months. Including these, the average hospital stay for the entire forty-five pa-

tients would be eleven and one-half weeks. If these six cases are excluded as exceptional, the average hospital stay for other patients with fractures of the femur treated by skeletal traction alone would be ten weeks.

*Leg Shortening.* The statistics regarding leg shortening are, of course, important. An analysis of the cases treated by skeletal traction alone shows that in forty-one recorded cases no shortening occurred in twenty-four; lengthening in four; and shortening in thirteen, or 31 per cent. In the thirteen cases having shortening this was from  $\frac{1}{2}$  to 3 inches, averaging  $\frac{7}{8}$  inch. It is well known of course that statistics of this sort can be very easily altered by only one or two exceptions; we had one case of 3 inch shortening, in a terribly obese, unruly individual, who suffered from incontinence, pressure sores, and ice tong difficulties.

*Knee Joint Motion.* The degree of knee joint motion following skeletal traction treatment was recorded in forty-three cases: thirty-one had normal knee motion; eleven, or 25 per cent had limitation of motion; in one case there was no motion (fused). Analysis of the eleven cases with limitation of knee joint motion shows that the *maximum* limitation was a total range of motion of only 20 degrees and the average limitation was a total range of 76.5 degrees.

*Return to Work.* The time that elapses between the date of injury and the date when the patient resumes his former work is, of course, important from an economic point of view. However, we have such data in only twenty-four cases. In the adults, the average length of time between the accident and return to work was seven and one-fourth months.

*End Result Rating.* The anatomic (A), functional (F), and economic (E) results of the injury have been evaluated in each case and expressed in terms of 0, 1, 2, 3, and 4, four being the highest rating and representing an "excellent" result; 3, a "good" result; and 2 or less, a "poor" result.

On this basis, the forty-four fractures treated by skeletal traction alone showed twenty-five (57 per cent) with a perfect rating of  $A_4F_4E_4$ . The remainder showed 30 per cent good, 5 per cent fair, and 8 per cent poor results. For all practical purposes, in 87 per cent of the cases the results can be considered satisfactory. If the average anatomic, functional, and economic ratings were expressed for the entire forty-four cases, they would be  $A_{3.5}F_{3.6}E_{3.5}$ .

This paper is not intended to be a plea for the use of skeletal traction in the treatment of fractures of the shaft of the femur; rather is it an honest attempt to show what happened when skeletal traction was used in the ordinary run of civilian patients by a combined group of general surgeons and orthopedic surgeons in a large city hospital. It is a kind of cross section study that represents the *average* end results that might be expected from the use of skeletal traction in the treatment of fractures of the shaft of the femur.

#### SUMMARY

Fifty-eight fractures of the shaft of the femur treated by skeletal traction have been analyzed and the following facts ascertained:

1. The average hospital stay of the patients was eleven and one-half weeks.
2. There were three cases of nonunion.
3. Thirteen cases of a total of forty-one, or 31 per cent, in which leg length was measured a year or more after treatment, showed some shortening, the average in the thirteen cases being  $\frac{7}{8}$  inches.
4. Knee joint motion was limited in eleven of forty-three recorded cases, or 25 per cent, the average limitation being a total range of 76.5 degrees.
5. The average time that elapsed between the date of injury and the date when the patients returned to their work was seven and one-fourth months.
6. The end result rating of these fifty-eight patients showed 57 per cent excellent, 30 per cent good, 5 per cent fair, and 8 per cent poor results.

# THE RUSSELL TRACTION METHOD OF TREATING FRACTURES OF THE FEMUR

JOHN DUNLOP, M.D.

PASADENA, CALIFORNIA

THIS report is not complete, due to the short amount of time at our disposal and the large amount of material to be reviewed. I wish here to express my appreciation of the valuable assistance given me by Dr. Stanley Haft in making the statistical review of the clinic cases. This study is based on a twofold experience:

1. In our private practice, where twenty-three out of thirty-seven cases of fractures of the femur have been treated by the Russell traction method, his teachings having been fairly closely followed throughout.

2. A review of clinic material, including the years 1936, 1937, and 1938, during which time 314 cases of a total of 741 fractures distal to the neck, received this method for at least part of their treatment. This group was under the supervision of a large number of attending surgeons and numerous residents, and can in no way be considered a study of a single group of cases, any more than if they had been cared for at separate hospitals. However, no attempt has been made to separate them according to services of any particular group of attending men.

To have a clear understanding of Russell's method of treating fractures of the femur, and before one undertakes to use this method, one should read carefully and understand every principle laid down by him in his now famous paper on the subject, published in the *British Journal of Surgery* in 1924.

The important thing to remember in fractures of the femur, is that when the shaft of the bone is broken, shortening occurs due to elasticity of the muscles of the thigh which are attached to the pelvis above, and to the lower leg bones below. Therefore, in order to restore the normal contour it is necessary to pull the thigh

out to its normal length. (Fig. 1.) Russell states "when we have accomplished this, every other structure in the thigh will be in a correct position, including the fragments." Accepting this as true, it then becomes necessary to design an apparatus which will produce just this type of force. In order to apply such a force most effi-

TABLE I  
INTERTROCHANTERIC AND SHAFT FRACTURES  
OF FEMUR—741 CASES

	Total Cases	Russell Traction
Intertrochanteric..	1936—142 1937—113 1938—161	17 29 114
	Total 416	160
Shaft.....	1936—122 1937—98 1938—105	44 41 69
	Total 325	154

Location of Shaft Fractures—Russell Treated

Upper Third	Middle Third	Lower Third
41	67	46

ciently, it must be so done as to produce the least amount of discomfort, as it is only under such conditions that muscle contraction is dissipated and the desired results obtained. Russell found that by handling a fractured thigh as illustrated (Fig. 1), with the knee flexed and at the same time with a pull on the lower leg, he could put the patient at ease so far as localized pain in the fracture site was concerned. It was to reproduce this force and to hold it indefinitely that the apparatus was devised. His own words are most im-

pressive, "I must devise some means of doing what I am now doing; something which will not tire, that will make the limb absolutely comfortable and in that way favour the return of mental quietude."

TABLE II  
INTERTROCHANTERIC AND SHAFT FRACTURES OF FEMUR  
TREATED BY RUSSELL TRACTION

	Inter- tro- chan- teric	Shaft
Days in traction*.....	36	40
Days in subsequent plaster fixation....	64	93
Disability average—months.....	8.7	8.66

\* None counted when in traction less than 21 days.

The apparatus consists of a sling below the knee, in order to lift the knee upward, and traction to the leg to pull the leg downward. It will be noticed from Figure 1

TABLE III  
COMPLICATIONS OF INTERTROCHANTERIC AND SHAFT  
FRACTURES OF FEMUR TREATED BY RUSSELL TRACTION

	Inter- tro- chan- teric	Shaft
Comminution.....	50	49
Compound.....	0	11
Loss of corrected position.....	31	8
In traction less than 21 days.....	25	2
In traction more than 21 days.....	6	6
Popliteal sloughs.....	2	
Foot drop.....	2	

that the surgeon is also making somewhat of a downward pull with the hand that is lifting the knee, and so the apparatus is set up to reproduce these pulls. (Fig. 2.) The sling under the knee is attached to a cord passing through a pulley overhead and a little more toward the foot of the bed, so as to simulate the line of lift somewhat toward the foot. The cord is brought to a pulley at the foot of the bed, then about a pulley attached or incorporated in a spreader block for the traction material, thence to another pulley at the end of the bed. The

pulleys at the end of the bed should be so placed as to keep the two cords leading from them to the spreader block parallel, as much more force can be obtained by such a set-up. Next, a pillow is placed under the injured limb in such a manner as to support the distal fragment to prevent the displacement due to the force of gravity, and also to elevate the heel so that it will clear the surface of the mattress. The foot of the bed is elevated on blocks, to prevent the patient, through the action of the counterweight of his body, from constantly sliding footward. (Fig. 3.)

TABLE IV  
MORTALITY OF INTERTROCHANTERIC AND SHAFT  
FRACTURES OF FEMUR

	Inter- tro- chan- teric	Shaft
Total cases.....	416	325
Total deaths.....	73	26
Russell traction—total cases.....	160	154
Deaths—Russell traction less than 21 days.....	14	11
Deaths—Russell traction more than 21 days.....	4	3

In order to fix the overhead pulley it is necessary to have some kind of a bar to which it can be attached, as well as a trapeze or handle, by which the patient may lift himself or change his position at will, without disturbing the fixation acquired from the balanced traction thus obtained. The few ways in which we have changed the parts, but in no way the principle, are as follows: The spreader block contains within it a wheel, rather than a pulley attached to a block. The clamp used for the stockinette contains within it a heavy felt padding, which seems to cause less irritation than the material bunched up under the knee.

Since the apparatus is so finely balanced, we use a small finely made rope or large cord, so as to produce as little friction as possible. In several of the illustrations which have been published, and even in the

illustration in Russell's first paper in 1921, the overhead pulley was placed too far toward the head of the bed, so that the pull

this pulley. The other most important thing in the set-up is the proper placement of the pillows under the thigh, to prevent

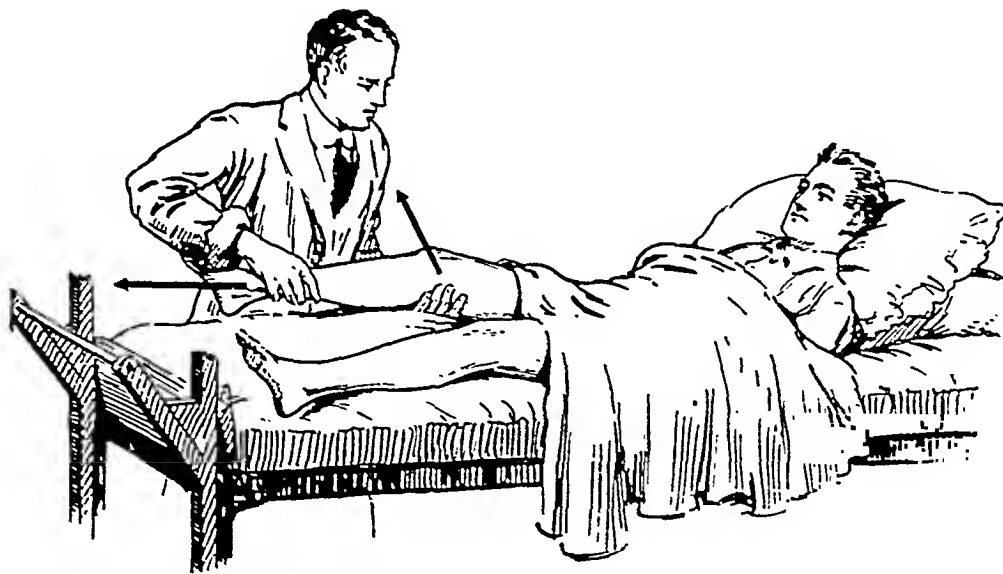


FIG. 1. Manipulation to draw out the thigh muscles, the direction of the force exerted being indicated by the arrows. (From Russell, in *Brit. J. Surg.*, 11: 491, 1924.)

was slightly up and antagonistic to the horizontal pull on the leg. One has only to have this apparatus applied to oneself to notice the tremendous difference in pull,

displacement due to gravity, and to produce the desired amount of knee flexion. One writer states that this knee bend should be a quarter of the total normal

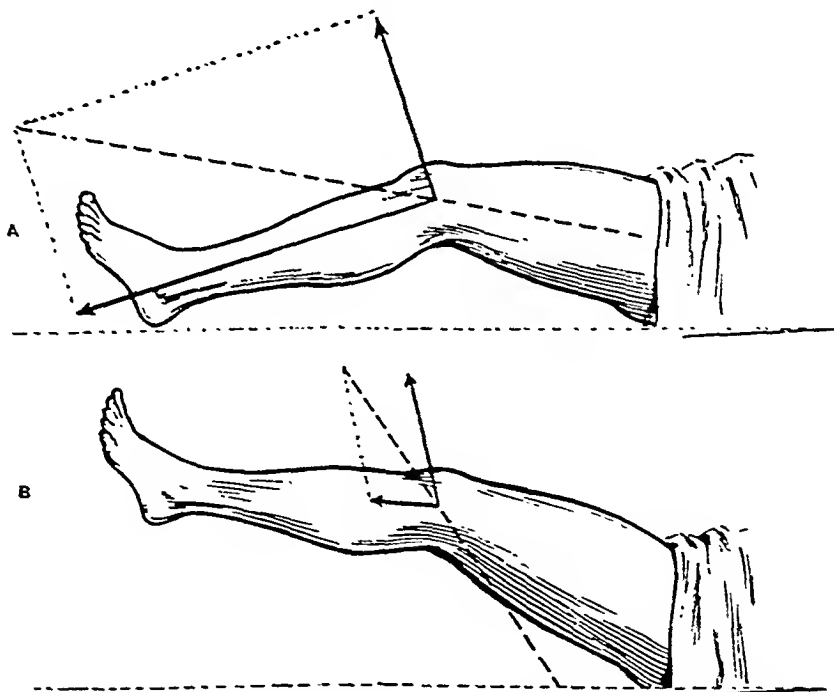


FIG. 2. Mode of action of the two forces employed. A, correct position. B, faulty position. (From Russell, in *Brit. J. Surg.*, 11: 491, 1924.)

depending upon the position of the overhead pulley, and the angle of the rope leading from the sling about the knee to

knee flexion. At least it should be such that the resultant force is a direct extension of the line of the thigh.



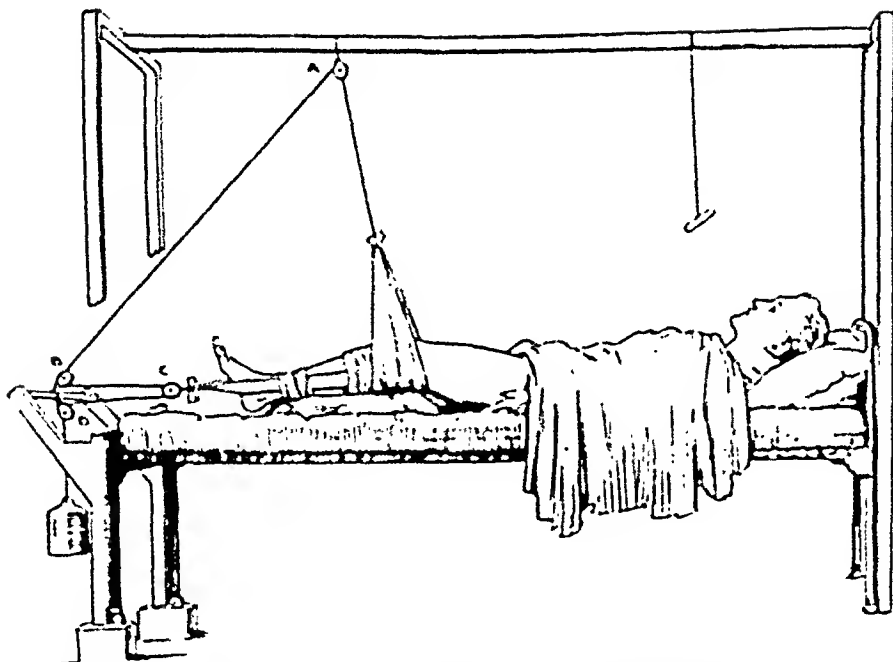


FIG. 3. Showing the application of the sling. (From Russell, in *Brit. J. Surg.*, 11: 491, 1924.)

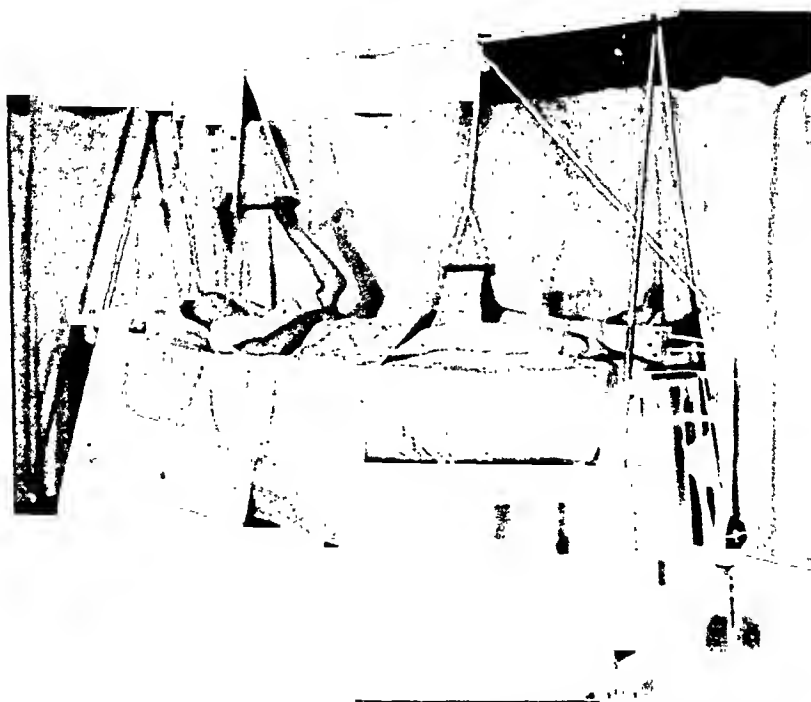


FIG. 4. Apparatus as used by the author, completely and correctly set up. Note (1) angle of knee flexion, (2) pillow to support leg, (3) angle of rope from sling under knee to pulley overhead, (4) parallel ropes from pulley attached to traction block to double pulley at end of bed, (5) elevation of foot of bed, (6) monkey bar to facilitate patient's handling himself for nursing purposes.

Russell states that 8 pounds of weight is sufficient to reduce most fractures in adults. In some rare instances 10 pounds may be

tion with the lighter weight. Possibly the most important detail is the position of the overhead pulley, a wrong position resulting

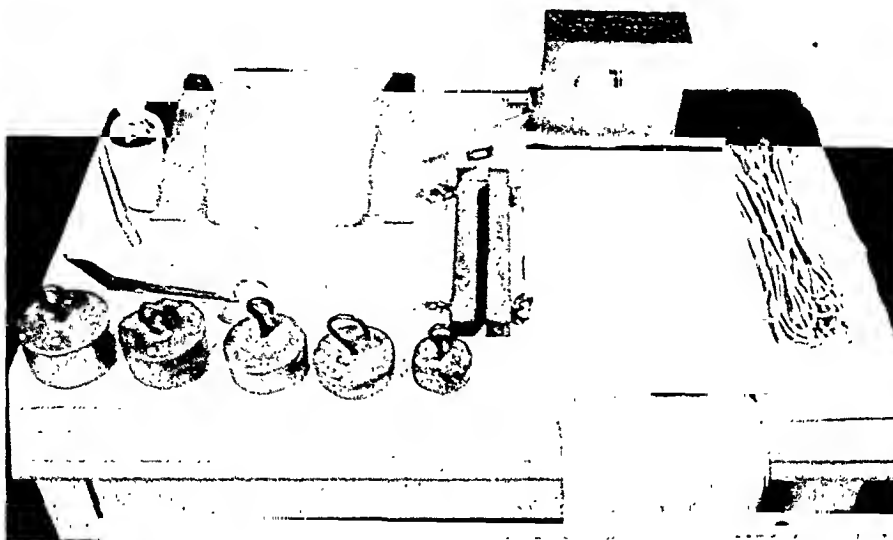


FIG. 5. Materials used in setting up Russell traction. From left to right in back row applicators, Ace, adherent, reinforced cotton flannel, Ace bandage, block with pulley. In front row: scissors, weights of 1 to 5 pounds, spreader clamp, 6 inch stockinette and felt, small sized rope.

necessary. In children, from  $\frac{1}{2}$  to 4 pounds are found sufficient. Others have found it necessary to use up to 12 pounds. From our

in a diminution of the proper pull from the lighter weight. It is also important not to forget the action of the adductor muscles.



FIG. 6. L. R., age 76. Injured October 16, 1937. Released December 21, 1937. A, fracture at base of the neck (sometimes termed intertrochanteric). B, perfect alignment the day after application of the Russell traction. C, excellent healing after forty-one days.

experience, I would say that other factors or mistakes in set-up may be responsible for the lack of ability to get a proper reduc-

If the leg is placed in too much abduction or if too great a weight is applied, which tilts the pelvis and in that way throws the

leg into abduction, the proximal fragment is drawn mesially by the tense adductors. Instead of helping the alignment by the

his type of traction. I should like to add emphasis on the necessity for proper arrangement of the pillows, which is of



FIG. 7. H. P. Injured March 13, 1938. End result October 25, 1938. Good alignment and healing of a badly comminuted intertrochanteric fracture of the left femur. Practically no coxa vara resulted.



FIG. 8. C. C. Excellent example of a subtrochanteric fracture treated by Russell traction. Resulted in good weight-bearing alignment.

addition of more weight, we have thus produced malalignment.

Russell particularly emphasized the elimination of pain and fear in the use of

such great value in preventing the malalignment due to gravity. Especially must one learn just how much of such support is necessary in those fractures where there

is a short proximal fragment which in the beginning has such a tendency to be drawn up into an acutely flexed position by the

sary for correction of the misplacement. Muscle spasm resulting from a condition of pain and fear is sure to throw the frag-



FIG. 9. E. S. Excellent example of what not to do. A, original film, showing intertrochanteric fracture. B, four days later, after application of Russell traction, showing fair reposition. Traction removed after thirteen days and a plaster cast applied. C, shows severe coxa vara, result of removing traction too early.

action of the ileopsoas muscle, and those cases with a short lower fragment, that tend to be drawn backward by the gas-

ments out of position, even though one has been successful in obtaining a correct alignment.

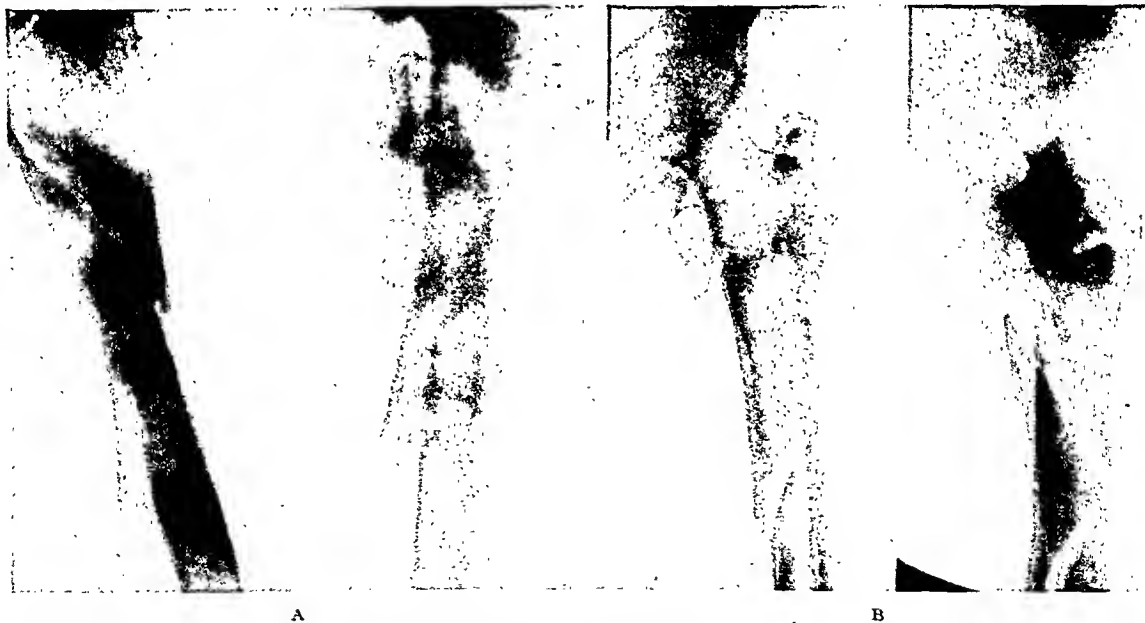


FIG. 10. L. H. Brought to hospital July 6, 1937 in plaster cast. A, badly comminuted and spiral fracture of left femur, involving the trochanter and including a fracture at the base of the neck. B, x-rays taken July 12, showing alignment of fragments after application of Russell traction.

trocnemius. It is particularly important, in the latter type of fracture, to determine the exact amount of flexion of the knee neces-

Ryan<sup>1</sup> stated in 1927: "In addition to the properties of contraction and of relaxation the living muscle exhibits the phe-

nomenon of 'tone.' By muscle tone is meant a state of continuous shortening or contraction which under normal conditions

the production of muscle tone. Royle has shown that the sympathetic nerves which supply the voluntary muscles have control



FIG. 11. Later films of the same case shown in Figure 10. This case is an excellent example of the value of Russell traction.

is slight in extent and variable. This condition is supposed to be dependent upon subminimal nerve impulses which are being continually sent into the muscles by external influences. It may be beneficial in

over 'plastic tone,' whereas the medullated nerves control the 'contractile tone,' both of these properties being the result of reflected sensory stimuli and in the production of deformity in fractures are due to the



FIG. 12. J. R. A, comminuted short spiral fracture of upper third of left femur. B, four days later, shortening has been overcome. C, excellent alignment and healing.

maintaining the nutrition of the muscle, regulating the heat of the body and causing a rapid response for a sudden voluntary contraction. The sensory and motor nerves therefore play an equally important rôle in

effort of the patient to maintain stability of the injured limb and sensory stimuli from the irritation of the fractured ends.

"It is essential, then, that the thigh should be immediately returned to a condi-

tion of muscular equilibrium by extension and a comfortable position as soon as possible after fracture occurs."

demonstrated in my own experience, and I feel that I cannot emphasize it too strongly.



FIG. 13. F. M. Gunshot fracture of the right femur, almost transverse. Application of Russell traction resulted in good alignment.

Gentleness in handling the patient and rearrangement of pillow support is of the utmost importance, not only in the initial set-up, but particularly throughout the

In a recent paper on the reduction of transcondylar fractures of the elbow I demonstrated<sup>2</sup> that such fractures could be quickly and more perfectly reduced with



FIG. 14. H. A., age 16. A, transverse fracture of the left femur with overriding. B, end result, showing shortening overcome, good alignment, excellent bone healing. The offset makes for stronger bone repair.

first few weeks when displacement may occur due to the production of either pain or fear. This point has been repeatedly

the patient constantly under the influence of a hypnotic. For that purpose I use sufficient morphine in doses over a period

of twenty-four hours, specifically to control just such contractile tone as Royle mentioned. With this eliminated through the

and that other types of treatment than Russell traction were to be preferred. Might it not be possible that these unsatis-

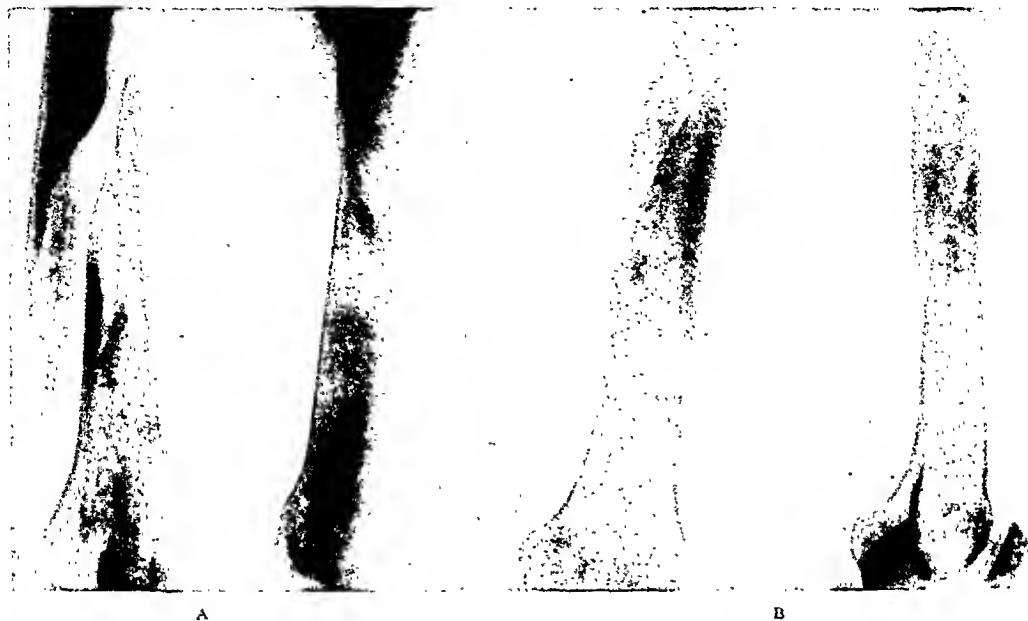


FIG. 15. H. F. November 5, 1936. A, simple spiral fracture at the junction of the middle and lower thirds of the left femur. B, end result, showing excellent alignment of fragments, no shortening and good healing.

action of the morphine, reduction is easily accomplished. Although I have not yet used morphine in this manner in fractures

factory results were due to the presence of pain and fear, because of improper use of the pillow support, or because a hypnotic

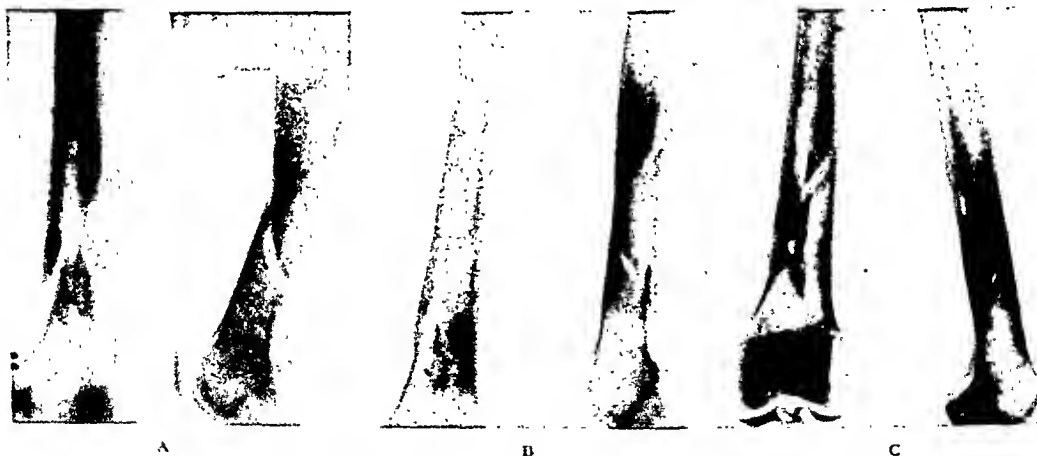


FIG. 16. W. C., age 28. A, comminuted spiral fracture of the middle and lower thirds of the shaft of the femur. June 11, 1936. Russell traction applied June 16, 1936, and patient discharged from hospital September 4. Eight pounds of weight used with additional lateral and rotary pull. B, July 28, excellent alignment. C, April 5, 1937, healing excellent, but bone repair not perfect after ten months. This is ascribed to too perfect reposition with little periosteal bone repair possible.

of the femur, I see no reason why the same results may not be expected.

Several reports state that fractures high and low in the femur satisfactorily reduced,

for complete relaxation was not used? If morphine is employed for this purpose, a sufficiently large dose should be given at regular four or six hour intervals until

reduction is complete or satisfactory, as determined by the portable x-ray. I wish to state specifically that this morphine is not used to relieve pain.

supports. During rounds at a hospital recently, a secretary called my attention to a possible reason for our having been unable to reduce an upper third fracture:



FIG. 17. L. W. W. A, badly comminuted fracture of lower third of shaft of left femur due to injury February 26, 1938. B, April 4, good alignment and healing well advanced.



FIG. 18. I. P. A, badly comminuted fracture of lower third of shaft of left femur. First seen one week after accident. Films taken in Thomas transportation splint November 25, 1938. B, February 20, 1939, after release from the Russell traction.

In connection with the taking of x-ray films by the portable machine, it would seem unnecessary to warn the surgeon that the technician should be most carefully instructed in no way to disturb the pillow

the technician had just taken a picture, and every pillow, which had been so carefully arranged, had been removed.

There is no question in my mind but that good results from the use of the Russell



traction method are absolutely dependent, first, on gentleness in handling, and next on following Russell's teachings to the most minute detail. The technique is not hard to master, and once acquired will give surprisingly satisfactory results.

There are few cases other than neck fractures in which the Russell traction is not preferable to other methods. However, when the leg of the same side is fractured below the knee, or there are skin injuries, it is not feasible. This applies equally to foot injuries of the same side. With complications and fractures elsewhere in the body it may be ideal.

The method requires a long hospitalization if used to the best advantage, but we have used it also in the homes of patients with the help of a portable x-ray machine.

Our review has shown that it is not good judgment to take patients out of traction early and apply casts, as in many of these cases reduction is lost. This is especially true of the intertrochanteric fractures, where the angle between the neck and the shaft had been well reduced and yet slipped into a coxa vara position. I doubt that a plaster cast can be so applied as to prevent such a deformity unless the so-called "well leg" fixation of Thornton is adopted. If it is necessary to discontinue traction, a well fitting caliper splint used continuously is preferable, and later it is of value in helping with early walking.

We use the Russell traction method because:

1. It is easily and quickly applied, even though shock may be present, and often it helps by the immediate relief of pain.

2. It is the most comfortable and least disturbing form of treatment for the patient, especially for nursing purposes, as he can so easily change position.

3. It can be applied without the use of an anesthetic, and unless complications arise a hypnotic is rarely used.

4. In older people it is of inestimable benefit in preventing chest complications, since the patient can sit up.

5. It least disturbs the initial blood clot at the site of fracture, which is so important in early union, especially if applied within a few hours of injury.

6. It least disturbs the general circulation of the leg.

7. It allows free access to the thigh for the dressing of compound wounds and abrasions.

8. An x-ray control study is easily made.

9. It is easier to determine when union is occurring.

10. There is less subsequent stiffness of the hip, knee, and ankle, and less atrophy of the leg muscles.

11. As the leg is in perfect balance, and fear and pain have been eliminated, there is no force other than gravity actively to dislodge the fragments.

After the apparatus has been applied and sufficient time has elapsed—usually a few hours—an x-ray study is made to see what has been accomplished, and adjustments are made according to the findings. These adjustments may consist of a change in position of the overhead pulley, a change in weights, the elevation or lowering of the foot of the bed, a change in the thickness or the position of the pillows under the thigh or leg, abduction or adduction of the leg, or possibly the addition of a lateral or a rotary traction.

When the position or alignment is found to be satisfactory no further changes are necessary, except possibly a change of the traction material on the lower leg. This occurs possibly once or twice during the time of treatment, and can be accomplished with the use of ordinary care without disturbing the position of the leg.

We consider reduction satisfactory when alignment for weight bearing is good, and shortening is overcome. I do not consider end-to-end apposition necessary, nor even favorable, for early and strong bone repair.

In our private cases traction is removed when we are quite sure that the x-ray shows sufficiently solid union to prevent angulation.

The clinic cases are necessarily handled differently. Due to the desire to make the hospital stay as short as possible and to make space for other patients, traction is removed as soon as sufficient fixation has occurred to allow application of plaster casts without loss of position, at which time the patients are removed to a convalescent home, or to their own homes. They are returned by ambulance from time to time for further observation.

In nearly all instances a caliper splint has been worn for protection until bone union is complete, accompanied by physiotherapeutic methods to restore as normal a muscular development as possible, and as much movement as can be obtained in all the joints of the leg.

#### CONCLUSIONS

The Russell traction is well adapted for the initial treatment of all types of fracture of the femur from the intertrochanteric down to the condyles. The immediate relief from fear and pain is most conspicuous. It practically eliminates the use of

hypnotics. With careful instruction in the use of the trapeze the patient soon learns to move himself freely, thereby eliminating all the complications of rigid fixation. Alignment is readily obtained quite as satisfactorily as is necessary, and the complication of stiff joints is minimized.

If early reductions and alignments are not obtained, possibly due to the interposition of soft parts, the difficulty is much more easily determined, and the necessary changes in treatment instituted. Complications such as circulatory disturbances are readily recognized, and compound wounds are open for observation at all times.

It is not a foolproof type of treatment, but with close observation on the part of the surgeon, it is remarkable how much satisfaction results from its use, both to the surgeon and to the patient.

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# FEMORAL SHAFT FRACTURES—PIN AND PLASTER METHOD

JOHN ROYAL MOORE, M.D.

PHILADELPHIA, PENNSYLVANIA

**A** CAST is applied from ankle to costal margin (Figs. 1 and 2); two circular windows are then cut in the cast, one covering the proximal fragment and the second covering the distal fragment. (Fig. 5.) The pins are inserted into the femur by means of a drill and hammer and then incorporated into the cast. (Fig. 6.) The cast is then cut in half by the two pins. (Fig. 7.) Reduction is obtained by means of traction, rotation, etc., depending entirely on the position of the fragments. (Fig. 8.) Repeated x-rays under the fluoroscope are made to determine the progress of the reduction. (Figs. 9, 10 and 11.)

*Caution.* The pins must go through only the two cortices but not completely transfix the part. (Figs. 12 to 17, inclusive.)

The plaster is maintained for twelve weeks. It is then bivalved and physiotherapy started to the ankle, knee and hip. The posterior shell is maintained in order to give adequate protection to the fracture site for a period of four weeks. The brace is prepared during this same period and is

usually applied at the end of the fourteenth week. The brace consists of a double bar, from ankle to groin, a long thigh lacer, a pelvic band, with or without an adjustable knee depending on the stability of the knee at the time.

Twenty-one patients have been treated by this method, thirteen adults and eight children. The average period for firm union in adults is sixteen weeks, in children twelve weeks. The average brace period in adults is four months, in children three months. Physiotherapy is administered to adults for three to six months, and to children for six weeks. We had no case of nonunion or delayed union. We have had one case of partial knee ankylosis due to fixation of the quadriceps secondary to extensive comminution at the lower end of the femur. (Figs. 18 to 21 inclusive.)

## SUMMARY

In the hands of the writer this method has proved a splendid means of handling fractures of the femur.

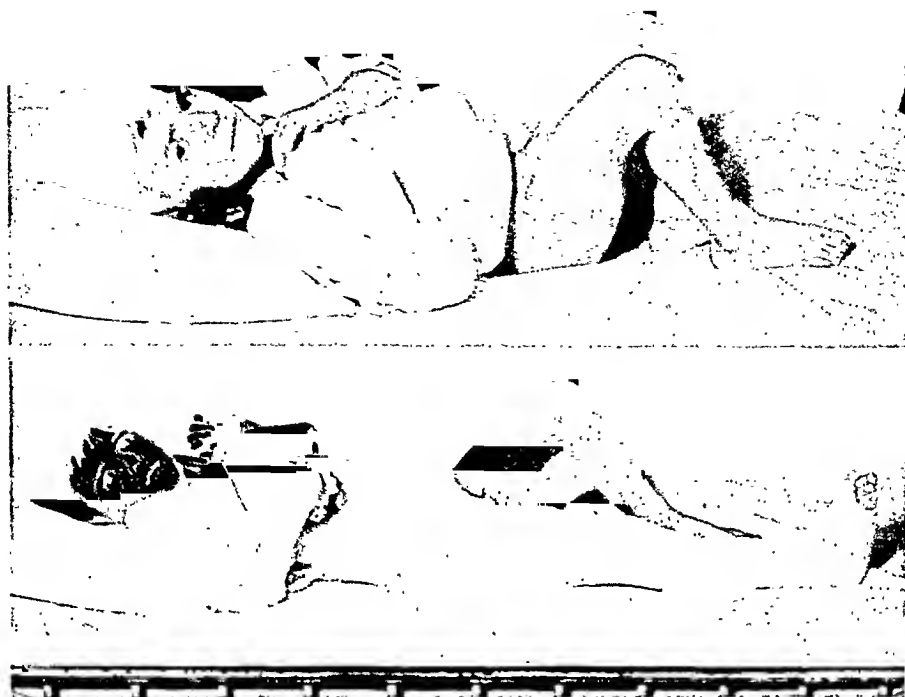


FIG. 1. Above shows the suffering patient and illustrates the fracture deformity.  
FIG. 2. Below we see the patient free of pain in a cast in which there has been no attempt to overcome the deformity.



FIG. 3.



FIG. 4.

FIGS. 3 AND 4. The accompanying x-rays demonstrate the status of the fracture as seen in Figure 2.

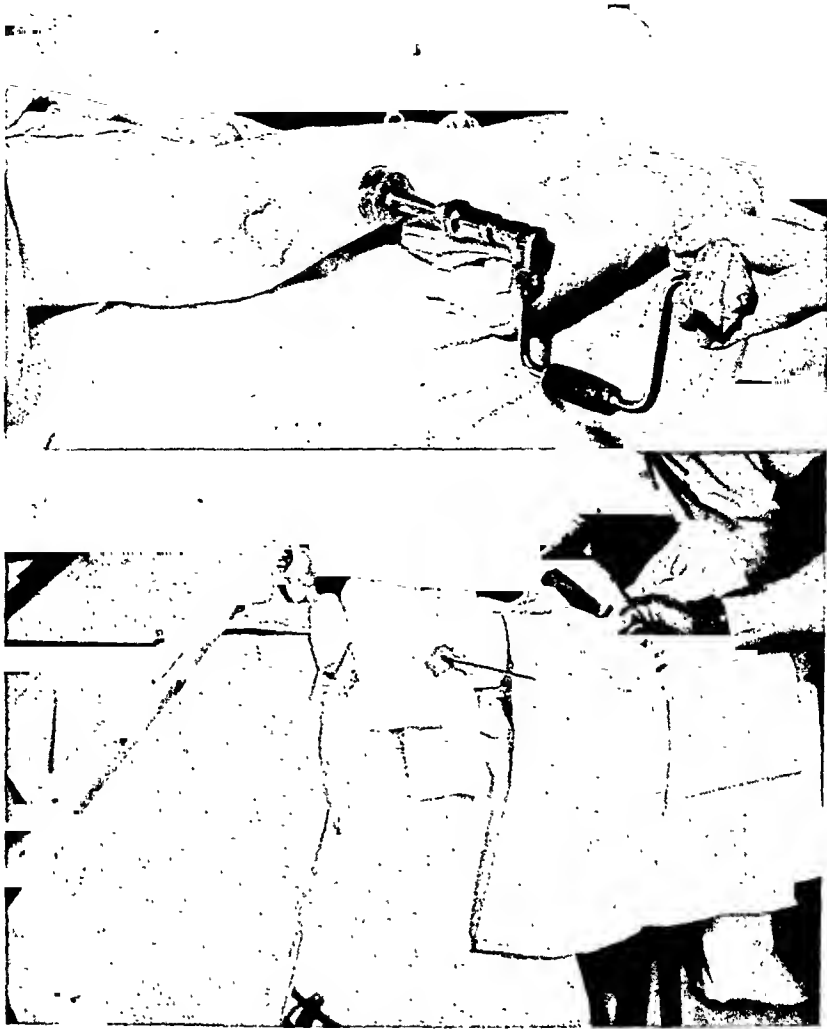


FIG. 5. Above.  
FIG. 6. Below.



FIG. 7. Upper.  
FIG. 8. Center.  
FIG. 9. Lower.



FIG. 10.



FIG. 11.

FIGS. 10 AND 11. Illustrate the post-reduction result.



FIG. 12.



FIG. 13.

FIGS. 12 TO 17. Examples of the handling and progress of a simple femoral shaft fracture in an adult.



FIG. 14.



FIG. 15.



FIG. 16.

FIG. 17.

FIGS. 14 TO 17. For descriptive legend see page 172.





FIG. 18.



FIG. 19.



FIG. 20.



FIG. 21.

FIGS. 18 TO 21. Reproductions depicting the progress of this fracture.

# FRACTURES OF THE FEMUR TREATED BY THE AUTOMATIC AMBULATORY METHOD OF ROGER ANDERSON

ALLEN F. VOSHELL, M.D.

AND

DOMINIC J. VERDA, M.D.

Baltimore City Hospitals

BALTIMORE, MARYLAND

THREE years ago an analysis of the leg fractures treated at the Baltimore City Hospitals was made in order to compare the results from each method used and the length of hospitalization period in each case. The usual methods of treatment for that period were utilized with at least average success, but the period of hospitalization seemed longer than necessary, which stimulated a desire to find some means of shortening the patients' stay in the acute wards. After due investigation and study, a skeletal splinting outfit known as the automatic ambulatory splint, as devised by Roger Anderson, was obtained and it has been used since then with considerable satisfaction.

During the past three years 600 fractures of the lower extremity, excluding the neck of the femur, intertrochanteric region, patella and feet, were treated. Of this number there were 118 fractures of the shaft of the femur, but only twenty-two were selected for treatment by the Roger Anderson method, while twenty-five tibial shaft fractures were similarly treated. Since this symposium deals only with femoral shafts, the analysis will be limited to the group of twenty-two cases of this type.

Each case was selected for treatment as specially suitable because one or more factors contraindicated other methods. The splint was not used promiscuously or blindly, but with due consideration and forethought.

The principles of use of the ambulatory splint are: good reduction under fluoroscopic and mechanical control; retention of this desirable position by lock devices

until a cast incorporating the bone pins can be applied; and early activity with the hip and knee uninhibited. Reduction is accomplished by inserting two pins at a fixed angle with each other into the proximal fragment near the trochanter and two straight pins through the distal fragment and thigh near the knee. The only necessary precaution is that the points of the proximal set of pins, joined together by a solid bar, must penetrate the inner cortex of the femoral shaft by about  $\frac{1}{4}$  inch.

With the patient lying on the fluoroscopy table, the fractured leg is placed in a special traction apparatus which attaches to the two sets of pins and by means of turn screws and movable rotation parts, the fracture is reduced (as determined by fluoroscopic observations). A short, strong cast is then applied from the groin and buttock to the knee joint, incorporating the proximal or so-called half-pin unit and the distal pins, leaving the hip and knee free. In brief, this apparatus requires the same attention to detail and the suggestions of its inventor as all others, but when properly handled it is simple and effective.

An analysis of the twenty-two cases of femoral fractures treated at the Baltimore City Hospitals by the above method, presents some interesting facts. Of these twenty-two cases, thirteen had received some type of traction previously and without successful reduction.

The average hospital stay was nine and one-half days in contrast to the twenty-eight days formerly necessary.

Two patients died, a mortality of 9 per cent. Both deaths resulted from bronchopneumonia. One patient aged 73, died four

days after reduction; the other, aged 68, five months after. The first patient had advanced Paget's disease and a mental disturbance, and the second had both cardiac and kidney involvements.

In six cases the fracture was still united at the end of three months. This was arbitrarily considered delayed union. However, all eventually united without further surgical procedure. The pins were removed between ten and fourteen weeks after reduction not a single infection having resulted. Recently the pins have been removed after six weeks to allow for earlier fragment end stimulation by impingement during weight-bearing. One or more casts are always applied after removal of the pins in order to retain proper alignment until union occurs. Fifteen patients returned to their former occupations or to school a few weeks after injury.

No real complications were actually met, although the possibility of embolism, infection and nonunion was always kept in mind. Too much traction can easily be applied and hence must be carefully avoided, for fear of nonunion.

Shaft fractures at all levels and of all types were treated in thirteen white males, three white females and six colored males. There were two cases from 1 to 9 years; seven from 10 to 19; one from 20 to 29; five from 30 to 39; one each from 40 to 49 and 50 to 59; four from 60 to 69 and one from 70 to 79.

The hospital stays varied as follows: eight days for the above first age period, four for the second, fourteen for the third, four for the fourth, twelve for the fifth, fourteen for the sixth, ten for the seventh and three for the last.

The following advantages have seemed thoroughly to justify the use of the principles and the splint as above described:

1. Short period of hospitalization with economic saving.
2. Preservation of muscle and joint movement and function.
3. Crutch ambulation immediately possible.
4. Slight after-care.
5. Early resumption of previous activities.
6. Early weight-bearing.

In spite of the several possible complications which might well occur with any skeletal procedure, only one, delayed union, has seemed likely to be a real factor with this method. In not one case did nonunion develop.

#### SUMMARY

Twenty-two cases of femoral shaft fractures of all types have been treated by the Roger Anderson automatic ambulatory splint and the statistics analyzed.

In spite of the apparently complicated procedure necessary to proper reduction, the results fully justify the use of the method in properly selected cases.

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# FRACTURE OF SHAFT OF FEMUR

## OPEN REDUCTION AND INTERNAL FIXATION

WILLIAM DARRACH, M.D.

NEW YORK CITY

*Reasons for Adoption of Open Method.* Open reduction and rigid internal fixation provide normal axis, normal length, earlier active motions, less constriction of circulation, shorter convalescent time and less permanent disability.

*Development of Method.* When this method was first used by me in 1908, Lane's method and technique were adopted as he described them at that time.

At first, operation was delayed from one to two weeks, but this time has gradually been cut down. At present, whenever the decision can be made immediately, the cases are treated as emergencies and patients are operated on as soon as they come into the hospital.

At first, a good deal of periosteal stripping was done during the approach and reduction. It was gradually realized that this interfered a good deal with the process of repair and delayed union. Now, the periosteal stripping and soft part damage are reduced to a minimum.

Formerly all patients were put up in plaster spicas for six to ten weeks. With the development of better material and better fixation, plaster has been given up and suspension is used, with earlier joint motion.

*Dangers and Precautions.* The three main dangers are infection, breaking of plates and screws and loosening of screws with angulation of fragments. In order to avoid the first, the most rigid non-touch technique is observed. Good material is the best protection against the breaking of plates and screws. The type of stainless steel used at present is far more satisfactory than anything else we have tried. Screws are less apt to pull out if careful attention is given to detail of insertion. This means the use of just the right size drill, with

careful drilling and insertion of the screws in order to get an exact fit without reaming out the thread.

*Experience with Materials.* At the suggestion of Dr. Adrian Lambert, plates made in the laboratory from sheet aluminum were substituted for the Lane plates which proved to be too brittle. As the wood screw has a tapering shank and the thread is not carried all the way to the head, it proved very inefficient. It not only crumbled the bone as it was driven home, but engaged a very small portion of the cortex. Machine screws were therefore substituted, but these involved cutting the thread with a tap after each drill hole. Then came Sherman fluted machine screws which cut out the process of tapping. At the same time, Sherman vanadium steel plates were adopted and for a number of years proved very satisfactory. Later it was evident that the same workmanship was not used and the plates began to break. A search was made for more reliable material. At present, we are using plates and fluted machine screws made of stainless steel, using Rezistal KA 2 Type 302 for plates and Rezistal FM 188 Type 303 for screws, made by the Crucible Steel Company of America. This is a high chromium, low nickel, steel whose formula is:

Carbon.....	0.07 maximum
Manganese.....	0.400- 0.65
Phosphorus.....	0.035
Sulfur.....	0.035
Silicon.....	0.300- 0.75
Nickel.....	8.000- 9.50
Chromium.....	17.500-19.00

*Plates and screws are removed only if there is infection, if they break or pull out and if they cause pain.*

*Operative Non-Touch Technique.* This means (1) double sterilization of all dry

goods; (2) dry goods, sutures and instruments handled by nurse with instruments in set-up; (3) thorough skin preparation

from the tip of greater trochanter downward, through the fascia lata and vastus lateralis. For the shaft, the important

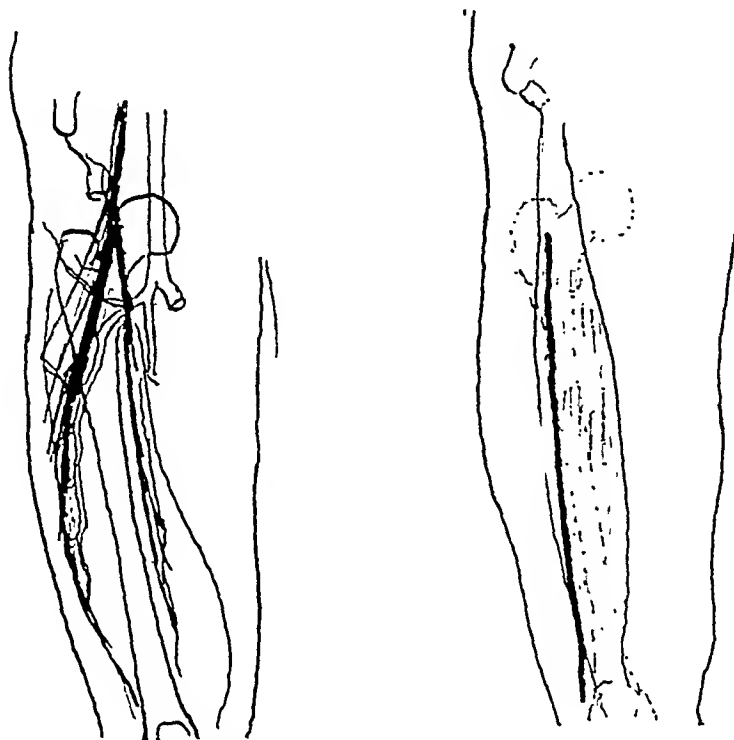


FIG. 1. Anterior approach to femur.

(less important); (4) superficial incision, towels fastened to skin edges with Michel clips, instruments discarded and gloves changed (operator and instrument nurse); (5) nothing that goes into the wound is touched even by gloved hand; (6) bleeding vessels controlled by electrical coagulation, large ones tied with silk; (7) fragments exposed with as little periosteal and muscle damage as possible; (8) reduction accomplished by manipulation with holding clamps, skids, elevators, traction, etc.; (9) reduction maintained rigidly by clamps while plate and screws are applied; (10) drill of exact size held steady, lest hole be too large; (11) screws inserted carefully so as not to ream out thread; (12) additional screws in separate plane, otherwise fixation is not rigid; (13) deep closure by few interrupted silk sutures; (14) skin closure; (15) Thomas splint for transportation to bed.

**Surgical Approach.** For the high upper third, there should be a lateral incision

anatomic structures are the descending branches of the external circumflex vessels and the muscular branches of the anterior femoral (anterior crural) nerve. These cross in front of the shaft just below the lesser trochanter and pass obliquely downward and outward, giving off a few vertical branches to the vastus intermedius, the large trunks passing out with the nerve into the vastus lateralis. If the approach can be made just mesial to this neurovascular bundle, there will be but little bleeding and no interference with the nerve supply of the muscles. In the usual lateral approach, both vessels and nerves are divided with unnecessary hemorrhage and interference with the life of the muscle. The incision is made in front, along the outer margin of the rectus and the rectus retracted inward. The mesial edge of the vastus lateralis is retracted outward, the descending branches of the external circumflex vessels and muscular branches of the femoral nerve

(anterior crural) recognized. The vastus intermedius is split mesial to the neurovascular bundle.

*Method of Postoperative Splinting.* If satisfactory fixation has been obtained, the lower extremity is put up in suspension immediately after operation, sometimes with a few pounds of traction. This is maintained for five to eight weeks and patients are allowed up on crutches with a brace or moulded splint.

*Motion Started.* Hip motions are started immediately. Knee motions are started from the twenty-first to the twenty-eighth day.

*Convalescent Treatment.* The bed period is from five to eight weeks or more. Then follow the use of a crutch with brace or splint without weight bearing and later the same with weight bearing. Full weight bearing follows at a varying interval, depending on the age of the patient, the character of break (whether transverse, oblique or comminuted), the character of the bone (whether cortical or cancellous), the amount of periosteal stripping and soft part damage, the rigidity of fixation, and the reliability of patient.

*Selection of Cases.* This method is used in children only when the closed method fails or no crepitus is obtained. For adults, it is routine if the patient accepts.

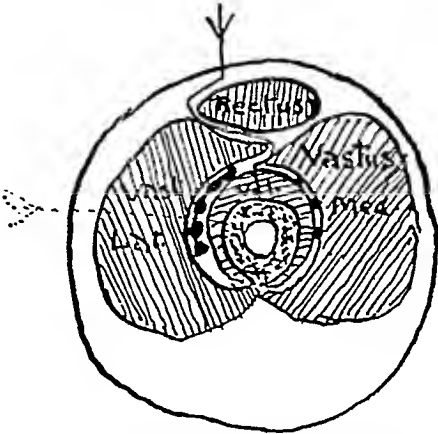


FIG. 2. Cross section of thigh showing anterior approach.

*Results.* Seven patients were not followed and two died. Of the remaining fifty-one, forty-seven returned to their former jobs. The other four were rated economically as 3 (on a basis of 4). Sixty cases in all were treated by open reduction and fixation.

In seven cases the plates broke, in eight the screws were loosened with angulation, and in sixteen the plates and screws were

TABLE I

Period	Average Days at Operation	No. of Cases	Character of Fixation*	Infection	Osteomyelitis	Postoperative Treatment	Broken Plate	Screw Loose	Metal Out	Full Return	Deaths	Shortening	Bony Union
1908 to 1913...	12.7	10	9 A. 1 V.	0	0	Spica	0	0	1 (23 yrs)	All	0	1 4 cm.	All
1914 to 1916...	....	7	7 V.	1—triv.	0	Spica	1	0	2	?	0	1 2 cm.	All
1928 to 1936...	11.	31	2 A. 2 Sc. 27 V.	2—triv. 1—ser.	1	17 Plaster 14 Suspension	6	7	8	27	2	3—1 cm. 1—1.5 1—2.5 1+2.3	All
1937 to 1939...	5.5	12	St. Ext. Sc. in 7	1—triv. 1—comp.	1	Suspension	0	1 Refracture	5	10	0	0	All
Total.....	....	60	.....	4—triv. 1—ser. 1—comp.	2	.....	7	8	16	47 out of 51	...	7 (1 more than 1 in.)	All

\* A = Aluminum.  
V = Vanadium.  
St = Stainless Steel.  
Sc = Screws.

removed. There were four trivial infections and two more serious infections resulting in osteomyelitis. One of these was in a compound fracture, already infected at the time of operation. All six resulted in bony union. In fifty-three cases of the total of sixty there was no shortening, while of the remaining seven, only one showed shortening of more than 1 inch. In one case there

was an increase in length of 2.3 cm. on the operated side. All sixty patients had bony union.

There were two deaths, one on the seventieth day, from a pyelonephrosis which antedated the accident and was later complicated by pneumonia. The second patient was electrocuted for murder two and one-half months after operation.



CHILDREN who have tuberculosis of the bone should have roentgenograms made of their chests at frequent intervals and if active pulmonary infection is found or suspected, they should be transferred to a tuberculosis sanatorium.

From—"Convalescent Care" (New York Academy of Medicine).

# THE TREATMENT OF MALUNITED AND UNUNITED FRACTURES OF THE SHAFT OF THE FEMUR BY MANIPULATION AND SKELETAL TRACTION\*

LEROY C. ABBOTT, M.D.

SAN FRANCISCO, CALIFORNIA

**M**ALUNION of a fracture of the shaft of the femur is generally regarded as a clear indication of the need for operation. Osteotomy alone, or osteotomy with some type of internal fixation of the fragments is usually employed. In ununited fractures the ends of the bones are freed from callus and scar tissue and a bone graft is applied to stimulate osteogenesis. Both malunited and ununited fractures of the femur, however, frequently show shortening due to angulation, displacement and overriding of the fragments, resulting in a deformity which is fixed by adaptive changes in the soft parts. This adaptive shortening cannot be overcome by any single procedure, and therefore the surgeon can only correct alignment and displacement by resection of the ends of the fragments. This results in a permanent disability due to shortening of the limb.

In my experience, operation may be avoided in patients who are seen during the early months following the occurrence of the fracture. In such cases the use of simple manipulation with freeing of the fragments in both malunited and ununited fractures, followed by skeletal traction on a Thomas splint, will often result in union with correct alignment and full length of the limb. In cases of many months' duration with complete solidity of union and overriding of the fragments, osteotomy should be performed, followed by the effective use of skeletal traction. Length and alignment secured in the simplest possible way, with avoidance of complicated operative procedures, should be our aim in the treatment of these cases and will, in the long run, yield the most satisfactory results.

The following paragraphs, therefore, will be devoted chiefly to the description of the technique of manipulation and the application of skeletal traction as I have used them in the treatment of malunited and ununited fractures of the shaft of the femur. Manipulation and skeletal traction can best be described as it is employed in (1) the treatment of malunited fractures; and (2) the treatment of ununited fractures.

## TREATMENT OF MALUNITED FRACTURES

In the majority of malunited fractures seen early, a careful examination will reveal tenderness over the callus. This is often found even in cases of several months' duration and it is a sign of the greatest importance because it is definite evidence that the callus is still the seat of active change and that it has not yet reached the stage of complete consolidation. Sir Robert Jones, recognizing this as a basic principle of treatment, pointed out that manipulation under anesthesia would often accomplish refracture, and if it were followed immediately by traction, faulty alignment could be corrected and the shortening greatly reduced. He often employed this method in connection with adhesive traction on a Thomas splint in preference to operation, and it was my privilege, while in England during the World War, to observe him carrying out such treatment with striking success. Later on, at the United States Base Hospitals at Savenay, France, I adopted the same procedure and the results were highly satisfactory.

After the War, at the University Hospital, Ann Arbor, Michigan, I continued to use this method with malunited and un-

\* From the Division of Orthopaedic Surgery, Department of Surgery, University of California Medical School.  
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united fractures, but in place of traction by means of adhesive tape, I used calipers applied to the condyles of the femur in order better to ensure complete restoration of the length of the limb. The description of the method and the results obtained were published in a previous article.<sup>1</sup>

Malunion of the femur is probably less common at the present time because of the more efficient methods of treatment now in general use. I believe, however, that this procedure should receive first hand consideration in those cases of malunion in which the clinical findings indicate incomplete consolidation of the callus.

The description of the technique of manipulation and the application of skeletal traction has been described in detail in the previous article mentioned above. Only the important points, therefore, will be referred to in the ensuing paragraphs.

*Technique of Manipulation.* A forty-eight hour preparation of the skin of the thigh and leg is a preliminary to manipulation. To avoid strain on the knee joint, padded board splints extending from the site of fracture to the sole of the foot are firmly bandaged to the lateral and posterior surfaces of the limb. Control of the upper fragment is secured by taking a hitch with padded rope just above the fracture. Under nitrous oxide anesthesia, with an assistant controlling the upper fragment by means of the rope, the operator quickly refractures by forcibly increasing the deformity. The fragments are further disengaged by internal and external rotations as well as by traction applied to the lower fragment. Often lengthening of an inch or more can be obtained at this time. A Thomas splint, with knee flexion piece attached, is then applied, forcing the ring against the tuberosity of the ischium. The thigh and calf are supported by flannel bands fastened to the uprights of the splint. I no longer use calipers, but prefer to secure traction by means of wire with a Mathews stirrup with the wire passed through cortical bone well above the level of the adductor tubercle. The technique of application

is familiar to all orthopedic surgeons and requires no further comment here.

The Thomas splint is suspended to an overhead bed frame, preferably of the Morrison type because it allows flexion, abduction and adduction of the limb without altering the position of the patient. The frame is simple and permits easy and quick adjustment.

To adjust the patient to the frame a rope is fastened to the anterior half of the Thomas ring, and the free end passed over two pulleys on the horizontal bar. To this free end, sufficient weight is attached to hold the ring firmly against the tuberosity of the ischium. The advantage gained by such an arrangement is that when the patient raises himself from the bed, the ring of the splint continues to hug the ischial tuberosity and a constant counter-extension is maintained. The lower end of the splint is fixed to a horizontal tubal arm, and traction is obtained by weight and pulley.

The average weight necessary is about 30 pounds (13.6 Kg.), and this is maintained until the injured leg is actually longer than its fellow. This usually requires from ten to fourteen days. Lateral displacement is corrected by the screw pressure pads. When accurate alignment is secured, the weight is decreased until the ends of the fragments are apposed, and this position is held securely until union has taken place as shown by clinical examination and Roentgen ray plates. The time required in the average case is generally twelve weeks.

Pressure sores beneath the Thomas ring are evidence of failure to care for the leather and the skin with which it lies in contact. This can be avoided by changing the area of the skin pressed on at frequent intervals during the first few days of traction, and by carefully washing and drying the leather ring at least twice daily. We have found that during the heavy traction, undue pressure against the tuberosity of the ischium can be effectively relieved by removing the pillows from

beneath the patient's head and by raising the foot of the bed.

The necessity of maintaining traction on

was performed and a Mathews wire passed through the lower end of the femur. Traction was applied on the Thomas splint with a weight

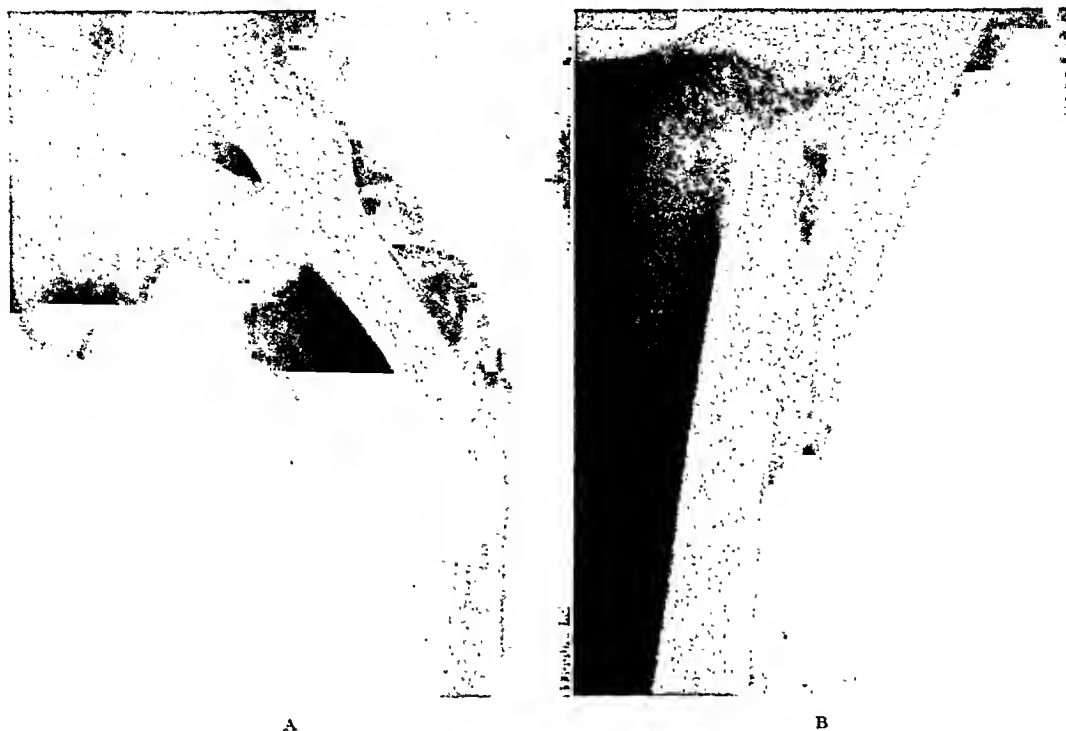


FIG. 1. Case 11. Anteroposterior and lateral views twelve months after injury showing union with angulation and overriding of the fragments.

the Thomas splint until the callus uniting the fracture has completely consolidated cannot be too strongly emphasized. It has been my experience that failure to observe this fundamental principle will often result in a recurrence of the deformity. This is illustrated by the following case:

**CASE 1.** M. G., aged 24 years, was admitted to the San Francisco Hospital on August 22, 1935. In an automobile accident on that date, she sustained multiple fractures of the pelvis, a compound fracture of the left ankle, fracture of the right fibula, fracture of the right femur and rupture of the bladder.

Immediate treatment was given for profound shock by blood transfusions and intravenous glucose. A suprapubic cystotomy was done twelve hours after the accident. The pelvis was supported by a sling. On September 27, a bilateral hip spica was applied. When this was removed on December 17, four months after the accident, there was union of the fracture of the femur with marked overriding of the fragments and moderate tenderness over the callus. On December 19, manipulation with refracture

of 25 pounds. On January 21, 1936, the roentgenograms showed distraction of the fragments and the weight was reduced. A hip spica was applied January 25, at which time it was noted that the fracture was not completely consolidated. The patient was discharged from the hospital with instructions to return for observation. On May 5, the hip spica was removed and definite lateral bowing of the femur was noted. This could have been avoided by a more careful follow-up and by permitting the patient to remain in the traction splint until the clinical examination and roentgenograms indicated solid union.

As a general rule fractures of the shaft of the femur in which the callus shows complete consolidation are not favorable for manipulation and refracture. In such cases separation of the fragments can be secured by osteotomy. It is important to stress here that any considerable degree of shortening cannot be overcome by operation alone. These cases require skeletal traction to restore full length to the limb and it should always be used subsequent

to osteotomy. I have employed the same technique for application of traction that is used in cases that have been refractured

knee, calf of the leg, ankle and foot became excoriated and badly infected. The patient began to have a high fever and was very ill,

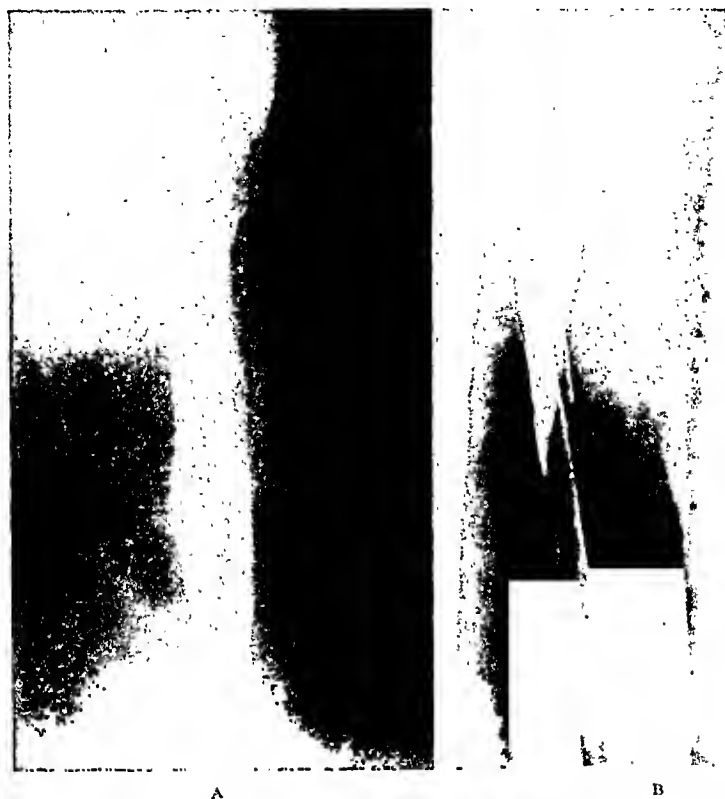


FIG. 2. Case 11. Anteroposterior and lateral views taken four months after the operation showing correction of the deformity, union and full length.

by manipulation. In other cases I have found skeletal traction with the Hoke plaster equally effective. Since these cases are of considerable duration the surgeon may find bone closing the medullary canals of both fragments. To reduce the chances of nonunion, it is best to remove this bone and to open the medullary canals at the time the osteotomy is performed. In this way union can be secured with full length and correct alignment without resorting to a second operation and bone grafting. These essential principles of treatment are well illustrated by the following case:

**CASE 11.** H. C., aged 17 years, was admitted to the Children's Hospital, November 1934. A fracture of the left femur had occurred when he was thrown from a horse on July 2, 1933. His treatment had consisted of traction with adhesive tape. The skin in the region of the

necessitating blood transfusions and other restorative measures.

The patient was transferred from Montana to San Francisco in October 1933, when I was called in consultation. At that time the boy's general condition was critical. The skin on the lateral and posterior surfaces of the ankle and heel had sloughed, exposing the tendons and fascia. There were also areas of sloughing about the lateral aspect of the knee and posterior surface of the calf. All the wounds were discharging pus. The left femur showed marked deformity. The treatment at this time consisted of dressings, securing of adequate drainage and building up the general condition of the patient.

Finally the patient was admitted to the Children's Hospital, sixteen months after his injury. Examination showed a marked deformity of the left femur with lateral bowing. The knee was ankylosed in full extension. The foot was fixed in a noticeable equinovarus and there

was loss of sensation of the skin supplied by the posterior tibial nerve.

Roentgenograms showed union with marked angulation and overriding of the fragments. (Fig. 1.)

On November 15, 1934 a stainless steel pin was drilled through the upper end of the left tibia just below its anterior tubercle. A Hoke plaster of Paris spica was applied with a special apparatus incorporated for traction on the left leg. This apparatus was provided with threaded bars with movable blocks. These were fastened above to the plaster of Paris spica and below to the pin which was passed through the tibia.

*Operation (November 30, 1934).* Through a muscle-splitting incision on the lateral aspect of the thigh the malunited fracture of the femur was exposed. The fragments were crossed like a letter X and held firmly in this position by callus. The medullary canals were walled off with bone. The operation consisted of freeing the fragments by cutting through the callus and opening of the medullary canals of both fragments.

Postoperative care consisted of traction by means of special apparatus until full length and good alignment had been restored. The apparatus was removed in three months and a plaster of Paris spica applied.

Four months after the operation the roentgenograms showed union with correction of the deformity. (Fig. 2.)

The patient was re-admitted to the hospital on September 10, 1935. At this time examination disclosed complete correction of the deformity of the femur. The knee was ankylosed in full extension. There was equinovarus deformity of the foot with ankylosis of the ankle and the joints of the tarsus. A loss of sensation of the entire sole of the foot was due to destruction of the posterior tibial nerve. Amputation was decided upon and performed through the middle of the leg on September 19, 1935. The convalescence was uneventful and the patient was discharged from the hospital on October 2, 1935.

He was seen last on September 15, 1938 when he was walking well with an artificial limb.

The same procedures described above may be used in malunited compound fractures of the femur which are infected. If consolidation of callus is incomplete manipulation may be employed but it should be gentle to prevent lighting up of

the infection. If this does take place, further opening of the wound to give better drainage may be indicated. In infected



FIG. 3. Case IV. Anteroposterior view taken twelve weeks after injury showing angulation of the fragments and separation of the screws from the lower fragment.

fractures with osteomyelitis and formation of sequestra, I believe that it is best to remove these sequestra and to obliterate the wall of the infected cavities as far as it is practical. The union of the fragments is then divided, and traction on a Thomas splint is applied to correct the deformity and to gain length as in the treatment of simple fractures. The wound is left open for drainage. The following case illustrates the use of this method in compound infected fractures.

**CASE III.** A. C., aged 17 years, was admitted to the University Hospital on January 19, 1939. He had sustained a fracture of the upper third of his left femur in June 1938. An attempt to reduce the fracture by the closed method had failed and open reduction was then resorted to

with the use of a bone plate and the application of skeletal traction. Later the plate broke but the traction was continued. In September 1938,

were found. With traction the fragments fitted together fairly well and increased length was readily obtained. The wound was packed with

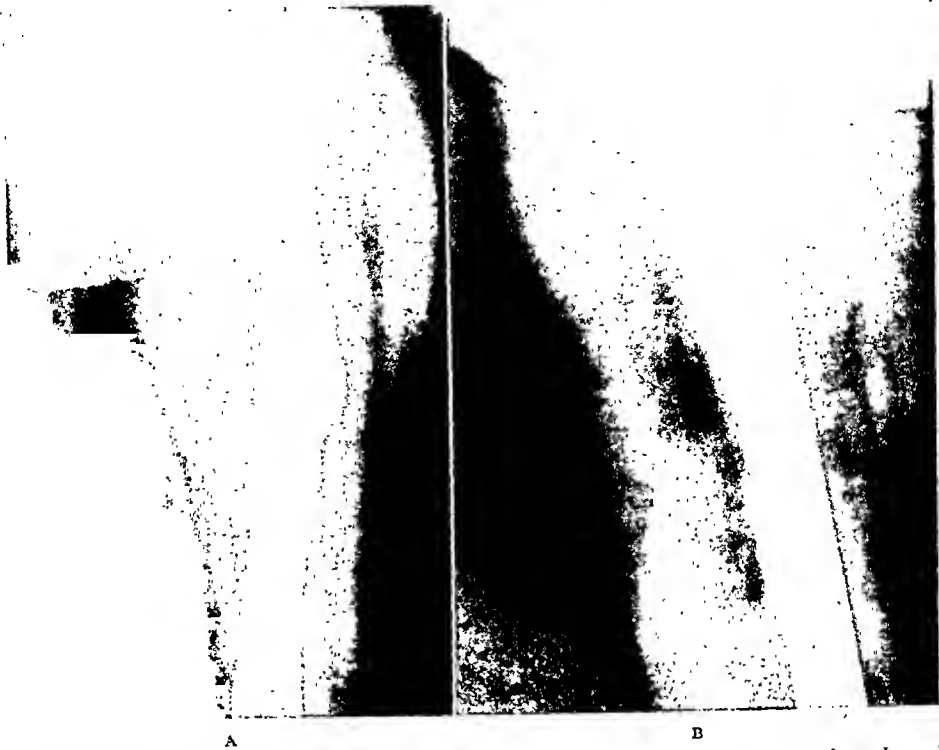


FIG. 4. Case IV. Anteroposterior and lateral views showing union with full length and correct alignment four months after removal of the plate, manipulation and traction.

the operative wound broke down with a discharge of pus. The wound was reopened and the plate removed. The fracture had healed with angulation of the fragments.

At the time of his admission, there was a marked, outward bowing of the left femur. The thigh muscles appeared atrophic, there was a shortening of the limb  $1\frac{1}{2}$  inches (4 cm.), and there were discharging sinuses at the operative wound. Roentgenograms showed an old transverse fracture at the junction of the upper and middle thirds of the left femur with displacement and overriding of the fragments. There was firm bony union. At the proximal, medial aspect of the distal fragment, a large isolated, well calcified fragment suggested a sequestrum.

*Operation (January 26, 1939).* Two Mathews wires were inserted, one in the upper tibia and the other in the lower femur. An incision was made on the lateral aspect of the femur, exposing the site of the former fracture. A large amount of dense scar tissue and callus surrounded the fragments. The medullary cavities of both bones were opened. No sequestra

vaseline gauze. The leg was placed in a Thomas splint and 20 pounds of traction were applied to the Mathews wire in the femur. Subsequent roentgenograms showed excellent alignment of the femoral fragments and the formation of a small amount of callus.

On April 11, 1939, the Thomas splint, wires and cast were removed. The fragments were movable at the site of the fracture. A walking spica was applied to facilitate the formation of callus. On April 20, the patient was discharged from the hospital wearing a plaster cast especially designed for weight bearing. Complete correction of the deformity of the femur had been obtained, with the beginning of union, although the formation of callus had been exceedingly slow. The patient remained under observation in the out-patient department.

#### TREATMENT OF UNUNITED FRACTURES OF THE FEMUR

The condition commonly found in delayed union of the femur is an unreduced

fracture, incompletely fixed in deformity by adaptive changes in the soft parts, and a varying amount of callus. In the majority of cases this callus has reached a stage of comparative inactivity. Therefore, the treatment indicated is reduction of the fracture and stimulation of osteogenesis which can be accomplished by manipulation and skeletal traction. Manipulation serves a two fold purpose; it disengages the fragments from a mass of fibrous tissue and callus, and, by so doing, it stimulates the callus to renewed activity. Skeletal traction will readily overcome the shortening, and if there is lateral displacement it can be corrected by the use of screw pressure pads.

Once the fragments are brought into accurate alignment, union can be hastened by percussing the callus with a rubber mallet and by placing constricting rubber bands above and below the site of fracture. This method was described by Hugh Owen Thomas, and was called by him "percussion and damming."

When there is evidence of union, consolidation of the callus can often be aided by the use of an appliance which permits partial weight bearing. In fractures below the level of the middle of the femur the Thomas walking caliper splint may be used. Above this level it is preferable to use a plaster of Paris spica applied next to the skin but designed to take partial weight on the ischium.

It is of vital importance to check these cases by frequent examinations and roentgenograms in order to prevent the recurrence of deformity.

In nonunion of the femur, I believe that manipulation and skeletal traction have a useful place, especially in those cases showing marked overlapping of the fragments. This method might be considered as the preliminary phase of the treatment, its object being restoration of length before open operation.

In my experience, the great difficulty in operations for nonunion in overlapping fractures of the femur is to secure end-to-end apposition of the fragments without

sacrifice of the bone length which will result in permanent shortening. If the length is gained by traction as a preliminary to operation, removal of the sclerotic bone and apposing of the freshened ends of the fragments becomes a comparatively simple procedure.

In some cases of delayed union it is advisable to place multiple drill holes in both fragments at the time the osteotomy is performed. With the use of this method, union may occur more rapidly, as illustrated by the following case:

CASE IV. A. D., aged 15 years, was admitted to the Children's Hospital on December 2, 1937. She had sustained a fracture of the left femur in an automobile accident on September 11. The fracture was operated upon and fixation of the fragments was secured by a steel plate. Immobilization was obtained by means of a Thomas splint for four or five days and then a plaster of Paris spica was applied. The spica was removed in seven and one-half weeks and marked lateral bowing of the femur was disclosed.

Examination disclosed, in addition to a marked lateral bowing of the left femur, a 2 inch shortening of the limb. There was tenderness over the callus and a springy motion upon manipulation. The condition was one of delayed union with marked deformity in a fracture of the middle third of the femur. This was confirmed by roentgenograms December 2, 1937. (Fig. 3.)

At operation on December 6, 1937, the site of the fracture was exposed by incising the scar of the former operation. The plate was removed and the fracture was found to be united only by soft callus and fibrous tissue. Manipulation corrected the faulty alignment and multiple drill holes were made in bony fragments to stimulate osteogenesis. A Mathews wire was placed through the lower femur. Alignment was maintained by traction on a Thomas splint and the application of Pearson pressure pads. Callus formed rapidly and a hip spica was applied on January 27, 1938. The patient was discharged from the hospital on January 30, 1938.

When the patient was last seen on April 15, 1938, there was no deformity, the legs were of equal length and she was walking without support. (Fig. 4.)

## DISCUSSION AND RESULT

It is impossible to include in this report a complete study of end results because of lack of records in the cases treated during and immediately following the World War. Of the ten cases where complete records are available malunion of from six weeks' to four months' duration was present in four. A satisfactory result with full length and good alignment was obtained with the exception of Case 1 above where a lateral bowing had occurred because of inadequate fixation for a sufficient period of time following manipulation. Union, good alignment and full length were secured in the four cases of ununited fracture. In the two cases which required osteotomy, one has complete union with normal alignment and full length, while the other, which is still under observation, has good alignment, full length and the beginning of union.

Objection has been made to manipulation on the grounds that it may produce a fracture at a site other than the original one, particularly where disuse atrophy of the bone is pronounced. In my experience this accident has never occurred, and I believe that it can be avoided by manipulating only where there is distinct tender-

ness of the callus, and carefully splinting the limb so that all the force is thrown directly on the site of the fracture.

## SUMMARY

1. Malunited fractures of the femur showing tenderness over the callus, even those of several months' duration, can be refractured by manipulation, and union with full length and accurate alignment can be secured by skeletal traction on a Thomas splint.

2. In cases of malunion with complete consolidation of the callus and walling off of the medullary canals, it is advisable to open the canals at the time the fragments are separated by osteotomy. Subsequently, skeletal traction should be employed to correct angulation and to restore full length to the limb.

3. Manipulation and skeletal traction can frequently be used to correct deformity and to promote consolidation of the callus in cases of delayed union of the femur. In nonunion, it is a valuable adjunct as a preliminary treatment to gain length before operation.

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# METHODS OF TREATMENT AND RESULTS IN COMPOUND FRACTURES OF THE FEMUR

H. WINNETT ORR, M.D.

LINCOLN, NEBRASKA

IN 1917 and 1918 a military committee recommended standardized splints for the use of the American army in France. If the use of those splints had been carried over into civil practice and if there had been less modification of splints and of methods of treatment, our results in compound fractures of the femur would be better than they are.

The commercial and scientific exhibits at our meetings indicate how far the modification of splints and methods has been carried.

Standardized splint methods and rules for treatment would contribute to the welfare of the patient and to the relief of everyone concerned in such cases. When he is confronted with a compound fracture of the femur, a surgeon often permits himself to be diverted from the fundamental requirements of the case (i.e., restoration of length and position) by such details as shock, hemorrhage, swelling, and pain, any or all of which might be relieved at once by prompt immobilization of the injured part in a proper splint.

The application of Thomas splints on the battle field was proposed by Sir Robert Jones in 1914. The great success of this plan is now a matter of history. This was the first time that first aid and correct treatment had been combined on a general plan. The compound fracture femur cases were protected at once and shock, pain, swelling and the other severe symptoms were prevented or relieved by this plan of immediate reduction of the fracture and immobilization of the fractured limb.

During 1918 the death rate in casualty clearing stations from gunshot fractures of the femur had been reduced to  $17\frac{1}{2}$  per cent. This represented an improvement of between 40 and 50 per cent from the first

days of the war. Sir Anthony Bowlby pointed out that there was a secondary death rate in the base hospitals of about 10 per cent and of approximately 3 per cent later in the home hospitals. So the eventual death rate was about 30 per cent in gunshot fractures of the thigh.

The American Orthopedic Association should insist upon certain minimum requirements for both emergency and subsequent treatment of compound fractures of the femur. We should set up standards as to methods and equipment and should encourage a present tendency to demand special qualifications of those who are to undertake the care of these difficult cases. If our program of national certification of specialists is to do the greatest good, the treatment of such conditions as compound fractures of the femur, the internal fixation of fractures and elective major amputations should be undertaken only by those surgeons who have been certified by the National Boards in General and Orthopedic Surgery.

One factor that has interfered with ideal fracture treatment has been the antiseptic treatment of wounds. It has now been demonstrated that frequent changes of antiseptic dressings and antiseptic irrigations are unnecessary. Early and complete fixation of fractures in correct position can now be carried out.

My own efforts in this direction originated in 1918-1920 with the Thomas double abduction splint as taught by Sir Robert Jones. To this splint as well as to the single ring caliper splint several surgeons at that time added the use of skeletal traction. Ice tongs and pins were employed in such a way that, even with frequent dressings, gunshot fractures of the femur were kept at full length and in correct position. Such a





FIG. 1. The patient is placed upon the traction table in such a way that immobilization of the parts to be operated upon can be maintained throughout the operation, and a plaster of Paris cast put on following the operation without any undue movement or disturbance of parts. When corrective manipulations or traction are necessary they can be carried out during or in connection with the operative procedure. The method of fixing the traction in the cast is indicated on the patient's left leg where moleskin adhesive plaster has been put on. The left hand of the operator rests at the point where adhesive plaster straps are to be turned back around the lower end of the plaster of Paris cast after that has been applied. In this way the traction is locked against the lower end of the cast before the foot portion of the cast is finished. This leaves the foot free so that it can be dorsiflexed to any degree desired as the final portion of the cast is put on. (From Orr, in "The Cyclopedia of Medicine," Davis.)



FIG. 2. The infected portion of the femur has been widely exposed, the soft parts are pulled gently apart by means of the retractor, and the entire area is being filled with vaseline gauze. No stitches, tubes or other materials are employed in the interior of the wound. (From Orr, in "The Cyclopedia of Medicine," Davis.)



FIG. 3. The vaseline dressing has been completed by filling the entire wound area with gauze, then applying a flat dressing over the surface which extends to some distance beyond the edges of the wound. This brings whatever drainage there is out to the edges of this vaseline pad, where it can be taken up by the cotton and gauze dressing. (From Orr, in "The Cyclopedia of Medicine," Davis.)



FIG. 4. The area of the operation and all of the other parts are now covered with cotton and bandages as a final preparation for the application of the plaster of Paris cast. It will be observed that the position of the patient has made no change at any time. Traction is maintained upon the feet and with the patient firmly against the perineal post until the upper portion of the cast is all finished and until the moleskin adhesive plaster straps have been turned back into the cast or until the skeletal traction or fixation devices have become secure in the hardening cast. (From Orr, in "The Cyclopedia of Medicine," Davis.)

program, however, involved much labor as well as disturbance of the patient. In the hands of those who were less expert, there

included the feet, knees and skeletal fixation devices in plaster of Paris after the patient had been properly adjusted in the



FIG. 5. The upper portion of the cast has now been finished, and the moleskin adhesive straps are being turned back around the edge of the cast and are being locked into the cast before the traction upon the feet is released. Full length and immobilization are still being maintained until this fixed traction has been completed. (From Orr, in "The Cyclopedic of Medicine," Davis.)

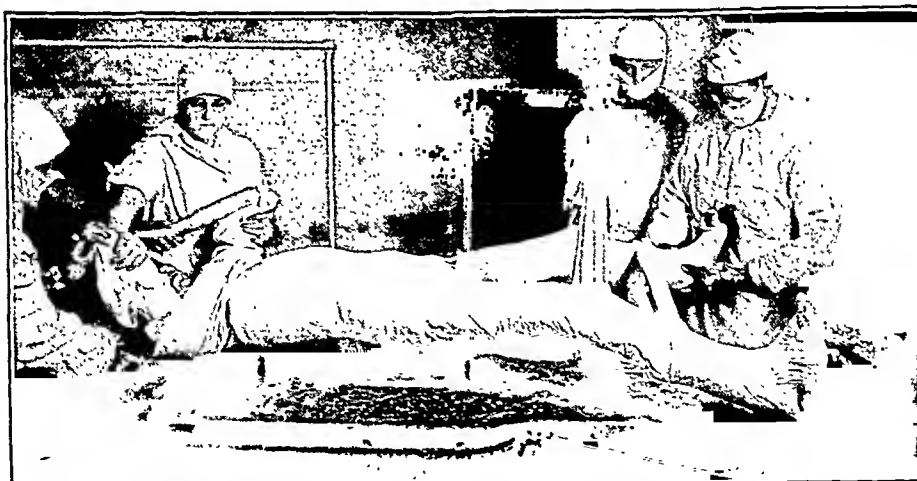


FIG. 6. The completed cast with all parts in correct position and completely immobilized indicates how efficiently length, position and control of all the parts are maintained in the finished cast. With patients who are inclined to muscle spasm or to be active, additional security is obtained by attaching a fairly heavy weight to the cross bar and having this weight hung over the foot of the bed, which is elevated to a height of from 8 to 12 inches. (From Orr, in "The Cyclopedic of Medicine," Davis.)

were inefficient splinting and many poor results.

During and after our war experience, I added plaster of Paris to this plan of treatment in Thomas splints. At first I

splint. Roger Anderson has recently called this "well leg traction." From this it was a short step to the plan I have employed ever since, i.e., the use of skeletal fixation pins in double leg casts or spicas. The infrequent

dressings method since 1921 has made it possible for me to treat all our patients by this plan.

We do not employ weight and pulley traction except as an adjunct for balancing the patient in the bed. Ice tongs, Kirschner wires and other less efficient fixation devices are no longer employed. Small rigid pins, imbedded in the plaster of Paris cast are routine with us in these, as well as in all other cases in which fixed length and position are desired.

The importance of consistency as to infrequent dressings has often been emphasized. Primary reduction of the fracture and skeletal fixation in plaster in correct length and position depend upon the attending specialist. But insistence upon correct after-care must permeate to every attending doctor, resident, intern, nurse and even to members of the family. Loss of control in the cast or exposure of the wound to secondary infection will often disturb the patient's progress toward recovery.

Sometime ago I had the following interesting clinical account from Dr. Calvin Smyth, Jr. of Philadelphia:

"A colored man stevedore of 50 sustained a compound comminuted fracture of the femur just above the knee joint when a heavy packing case fell on him. In addition to the fracture of the femur he sustained fractures of the nose and maxilla, and multiple lacerations of the face. He was in profound shock upon admission. The upper fragment of the femur was protruding through his overalls. After instituting measures for the relief of shock, the wound on the outer aspect of the thigh was flooded with iodine and covered with a sterile dressing.

At the end of twenty-four hours under local anesthesia the wound was cleaned, the protruding bone replaced and the wound packed lightly with iodoform gauze. Tongs extension was applied and the limb suspended in a Thomas splint. Plaster was not applied because of the necessity of using tongs; we had at that time no experience with Orr's plan of incorporating the tongs in the plaster.

During the following three weeks the wound was not disturbed by any sort of dressing and the patient had no elevation of temperature

whatever. During the fourth week, the house officer, becoming alarmed by the odor of the dressing, removed the packing, swabbed the wound with mercurchrome and repacked with plain gauze. On the following day the temperature rose sharply to 103 degrees and from that point the patient was septic and required multiple operations for relief. Union of the fracture occurred, but the infection in the depths of the wound prolonged hospitalization for many months."

Dr. Smyth commented, "This case serves to demonstrate an instance where early treatment was effectual, and in which infection appeared only after three weeks, following a meddlesome dressing. From our experience with other cases, we believe that had this man been in plaster with no dressing for five or six weeks, no infection would have taken place."

I treated a patient in Mexico City with Dr. Farill two years ago in which the patient had been in bed for over a year with malunion of a femoral fracture just above the knee. She had several draining sinuses about the knee and equinus deformity of the foot.

At our operation skeletal traction and manipulation were employed to correct the fracture deformity and bring the limb down to correct length and position. The draining sinuses were enlarged. Tenotomy of the Achilles tendon had to be done to bring the foot to a right angle with the leg. This patient had no postoperative complications. She recovered completely in a few months and has been walking on a useful limb ever since.

Early in my experience with infrequent dressings, I suggested consideration of this method for military surgery. However, in Washington, my proposals were considered too radical a departure from usual surgical practice. My own experiences with gunshot wounds had convinced me that drainage and packing of compound fractures and skeletal fixation in plaster of Paris casts were just as feasible in gunshot fractures as in other infected wounds. It has been a matter of some satisfaction to me, there-

fore, that recent communications from the military areas in Spain have borne out my views in regard to this matter.

Dr. J. Trueta Raspall, who was on duty in the vicinity of Barcelona and in Catalonia, wrote to me some months ago and sent a copy of his book on "The Treatment of War Fractures," first published at Barcelona. He reported a large number of cases successfully treated by the methods which I have described. I have since received another letter from Dr. Raspall, written in London, after his departure from the Barcelona area upon the entrance of General Franco. His letter, dated April 11,

1939, states: "I am very grateful to you for your last letter. Here I am in London advertising your method which I used 1,073 times, out of which only six patients died. Soon there will appear in the *London Lancet* an article telling about the part I took in the Spanish War, where, as Director of Barcelona, I had a big chance for putting into practice your method. In the army, where I insisted that the method should be used in all cases, the number of times that I put it into practice amounts to 10,000. The gas gangrene that made so many victims suffer at the beginning of the war, has now almost disappeared.



THE primary aim of debridement is the removal of tissue which has been so damaged that it will no longer heal readily, and not, as is sometimes thought, the removal of bacteria.

From—"Surgery of the Hand" by Couch (University of Toronto Press).

# CHEMOTHERAPY IN THE PREVENTION OF INFECTION IN COMPOUND FRACTURES

ROBERT W. JOHNSON, M.D.

BALTIMORE, MARYLAND

COMING at the end of this excellent symposium on fractures of the femur, I still feel like a tail that is about to wag the dog. This is because the subject which I present is the application to our orthopedic problems of one of the most astounding and important advances in medicine in many years. I have but to ask you to use your imagination in considering two questions to illustrate to you its extreme importance. First, try to visualize how our difficulties and tragedies in the last war would have been multiplied without tetanus antitoxin. Then try to imagine the godsend that the elimination or control of sepsis and gas gangrene will be in the next war. Profound post-traumatic sepsis and gas gangrene are fortunately not common in civil life, and one has to turn to war or mass catastrophes to get the really dramatic effect of the newest triumph of chemotherapy.

Chemotherapy is not new, for where in primitive life have witch-doctors and shamans not had their choice brews to heal the wounds of battle or chase? One cannot even pause to tell off some of the predecessors of sulfanilamide—from the well-chewed quid of herb or tobacco, through laudable pus to carbolic acid and Dakin's solution. All these have been local in application and worked from the outside. Only antitoxic sera acted as systemic protectors against wound infections and made the patient able to cope with the infection from within. While medicine had been scoring its chemotherapeutic victories over malaria, syphilis and sleeping sickness, and preventing smallpox, typhoid and diphtheria by inoculation, surgical infections, except tetanus, were still vulnerable only from without.

Then came the reports from workers in Germany and France—Domagk, Levaditi, and others, in 1935 and 1936, closely followed by Colebrook's and Kenny's excellent experimental and clinical paper in 1936 in England, showing the control of hemolytic streptococcus infections by para-amino-benzene sulfonamide. These almost miraculous reports were checked and amplified in this country, first by Long and Bliss in the biological laboratory of Johns Hopkins, and reported to the Southern Medical Association in November, 1936. Since that time the literature has been bursting with reports of its trial and use for almost every surgical infection. Erysipelas, puerperal fever, gas gangrene, gonorrhea, all seem to yield to this prince of drugs. Bohlman reported its use in gas gangrene resulting from compound fractures in July, 1937.

I first came across the miracle worker personally when the son of close friends of mine cracked up in a plane, and in thirty-six hours had a fulminating gas bacillus infection in a terrible compound tibia and fibula fracture, in addition to many other injuries. While I was urging amputation as an immediate necessity on the surgeon in charge, a medical colleague begged for a twenty-four hour trial of prontosil, as it was then called, and I reluctantly gave in. Conviction and conversion followed.

From this case in which the drug succeeded in controlling an established virulent mixed streptococcus and gas infection, it was but a simple and rational step to think of using it for prevention. So, after discussing the toxicity of the drug with Drs. Long and Bliss, we felt more than justified in ordering its routine use as a prophylactic in all cases of serious com-

	Date and Accident	Compound Fractures	Other Injuries	Duration Prior to Admission, Hours	Time of Initial Dose	Surgical Procedure	Serum Therapy A.T.S., Perfringens
1. B. F. 23 years	2/6/38 Airplane crash	Left tibia and fibula	Fractured spine, concussion. Fractured ankle, right; fractured tibia, right. Multiple lacerations.	3	30 hours	Debridement, splinting	1500-4000 500 c.c. blood
2. C. N. S. 17 years	10/10/38 Struck by auto	Comminuted left tibia and fibula	Lacerations	2	3 hours	Debridement, reduction, cast	1500-4000
3. J. C. B. 65 years	12/6/38 Struck by auto	Comminuted left femur	Multiple fractures of pelvis, left tibia and fibula. Bladder injury.	1/2	6 hours	Splinting, transfusion of 500 c.c.	1500-4000
4. L. R. 56 years	10/21/38 Struck by auto	Left tibia	Right tibia	1	1 hour	Debridement, reduction, cast	1500-4000
5. D. M. S. 7 years	1/18/38 Struck by auto	Right femur Left femur	.....	1	10 days	Toilet, reduction	1500-4000
6. A. H. 61 years	12/9/38 Struck by auto	Right tibia	Left fibula. Concussion	2	4 hours	Toilet, splinting	1500-4000
7. F. C. P. 22 years	4/24/39 Struck by auto	Left tibia and fibula	None	1	3 hours	Toilet, splinting	1500-4000
8. H. A. 62 years	11/7/38 Struck by auto	Left tibia and fibula. Right tibia	Right intertrochanteric fracture. Head injury.	2	4 hours	Debridement, splinting, transfusion	1500-4000
9. R. B. 31 years	5/22/38 Motorcycle accident	Right tibia and fibula	None	1	4 hours	Toilet, reduction, splinting	1500
10. W. G. 7 years	8/23/38 Struck by auto	Right tibia and fibula	None	1	3 hours	Toilet, reduction, debridement, closure	1500-4000
11. I. B. 17 years	12/25/38 Auto accident	Left tibia and fibula	None	12	15 hours	Debridement, closed reduction	1500-4000
12. F. K. 21 years	12/25/38 Motorcycle accident	Right tibia and fibula	None	1	30 hours	Debridement	1500-4000
13. G. S. 4 years	9/9/38 Fall	Humerus and elbow	None	1	24 hours	Closed reduction, toilet	1500-4000
14. J. G. 5 years	6/29/38 Struck by auto	Left femur	None	1	2 hours	Closed reduction, toilet	1500-4000
15. H. L. 59 years	4/20/38 Struck by auto	Right tibia	Left tibia and knee joint	1	3 hours	Debridement, closed reduction	1500-4000
16. J. E. 19 years	11/28/37 Struck by train	Left tibia	Muscle tears	1	24 hours	Debridement, open reduction	1500-4000
17. M. D. 37 years	8/6/37 Fall	Right Pott's fracture	None	1	4 days	Toilet, closed reduction	1500-4000
18. D. H. 45 years	5/23/38 Fight	Right humerus	None	1	3 hours	Toilet, closed reduction	1500-4000
19. F. C. 19 years	9/9/38 Caught in machinery	Right radius and ulna	Right ulna, soft tissue	1	2 hours	Toilet, closed reduction	1500-4000
20. L. B. 50 years	12/14/37 Struck by auto	Right tibia and fibula	Right femur, lacerations	1	3 days	Debridement	1500-4000
21. M. M. 17 years	3/21/38 Auto accident	Right tibia and fibula	Laceration, head injury	1	2 hours	Debridement, p i n traction	1500-4000
22. J. C. 5 years	4/19/38 Struck by auto	Right tibia and fibula	.....	1	3 hours	Debridement, closed reduction	1500-4000
23. C. W. 50 years	6/6/38 Struck by auto	Right tibia and fibula	Laceration	1	2 hours	Debridement, closed reduction	1500-4000

## RT I

Initial Dose	Blood Sulfanilamide 24-48 Hours	Total Dosage	Cultures	Complications	Duration of Hospitalization, Days	Result	Discussion
80 gr. 200 gm. in next 48 hours	No record	30 gm.	<i>B. welchii</i> , hemolytic streptococci, saprophytic	Extreme shock	169	Excellent despite fulminating gas gangrene and multiple other injuries. Long hospitalization not due to compound fracture, but to head and spine injuries.	Sulfanilamide undoubtedly saved this leg and also probably saved life.
20 gr.	No record	300 gr.	Hemolytic, staphylococcus albus, <i>B. subtilis</i>	None	20	Excellent. Union in three months.	No deep infection, though skin and fascia area became infected by hemolytic staphylococcus and subtilis.
20 gr. 40 gr. daily	No record	320 gr.	Staphylococcus aureus, <i>B. coli</i>	Myocardial failure, shock.	14	Died of myocardial failure and urinary comp. Not associated with compound fracture.	Sulfanilamide effective as against infection of leg, but patient died of other complications.
20 gr.	None	240 gr.	None	None	22	No infection. Delayed union.	No infection. Delayed union due to faulty co-operation.
10 gr.	None	100 gr.	Hemolytic streptococcus	Abscesses, erosion left femoral artery; numerous secondary hemorrhages, ligation femoral artery.	204	Healed eventually.	Sulfanilamide not given prophylactically and hemolytic streptococcus infection barely controlled eventually. Patient almost died.
10 gr.	None	270 gr.	None	None	32	Good healing.	Wound clean.
20 gr.	None	180 gr.	None	None	18	Good healing.	Wound clean.
60 gr.	None	190 gr.	None	None	58	Good healing.	Wounds clean. Consider this case almost miraculous in preventing infection.
10 c.c. prontosil	None	300 gr.	None	None	11	Healed—clean.	No evidence of infection in wound. No cultures.
5 gr.	None	160 gr.	None	None	7	Healed.	No infection.
80 gr.	None	300 gr.	None	None	10	Healed.	No infection.
80 gr.	4 mg. per cent	320 gr.	<i>B. welchii</i> , streptococcus, saprophytic	Gas gangrene	14	Amputation.	Infection fulminating. Required amputation.
20 gr.	.....	100 gr.	None	.....	14	No infection.	
20 gr.	.....	70 gr.	None	None	28	No infection.	
30 gr.	None	280 gr.	None	Anemia, cyanosis	105	No infection	Long hospitalization due to fracture both legs and bad home condition.
40 gr.	2.5 mg. 6.3 mg.	.....	<i>B. welchii</i>	Temperature 102-24 hours, acute gas infection	60	Infection—Recovery.	Delay in use of sulfanilamide allowed start of gas bacillus infection despite prophylactic serum.
25 gr. q. 4 h.	8.2 mg. 2 days after start	600 gr.	<i>B. welchii</i> , proteus, coli, anaerobic	Temperature 102.4 in 24 hours, acute infection	52	Infection—Virulent gas and mixed.	Delay in use of sulfanilamide allowed another gas bacillus infection to get started, but then checked it without loss of limb.
60 gr.	None	220 gr.	None	.....	16	No infection.	
60 gr.	None	420 gr.	Hemolytic staphylococcus, albus(?)	Required open reduction — 9/12/38.	12	Delayed union.	Infection effectively controlled.
15 gr.	.....	180 gr.	None	Lues, psychosis	175	Prolonged wound infection.	Not enough sulfanilamide given to be effective.
80 gr.	10.8 mg. 9.2 mg.	650 gr.	None	Gonorrhea	29	Non-union.	Effective in preventing infection. Traumatic psychosis a factor is non union.
45 gr.	.....	105 gr.	None	None	80	Excellent.	Large area skin slough required long hospitalization. No infection.
20 gr.	.....	240 gr.	None	None	30	Excellent.	No infection.



pound fractures on our services, and we have had no reason to regret it. The only destructive operation due to infection since the use of sulfanilamide routinely is in its self a triumph for the drug, for it occurred in the only case which, through human fallibility, failed to receive any medication for thirty-six hours after admission. Even in amputating that leg I was in bad repute with the medical staff, who would have had me preserve an entirely necrotic leg to prove they could have saved the patient anyhow.

Our fracture service at Johns Hopkins Hospital is not a very large one and we shared it with the surgical staff, but when we checked up on the compound fractures, recent enough to be treated with sulfanilamide, we were surprised to find so few. Perhaps the worry and trouble they give us serves to multiply them in our memories.

Dr. Hammond of the Emergency Hospital, Easton, Maryland, who has an active and excellent fracture service in that rural community, has coöperated with me in using similar prophylactic measures and allows me to include his series, from which I draw an illustrative case.

While the four cases I have selected for individual citation seem to me to point the real moral, let me briefly summarize the whole group of cases treated so far.

A total of thirty-six very severe contaminated compound fractures have been treated with sulfanilamide. Many of these patients had other serious injuries as well. Ten had gross infection in the wounds, five with *B. welchii* and five with hemolytic streptococci on smear or culture; others with staphylococci, *B. coli* and saprophytic organisms as well. There was one amputation, as noted earlier. There was one death in an uninfected case from complications arising from a fractured pelvis and myocardial failure. In the only four patients who became seriously infected, the drug had been used too late (after twenty-four hours, thirty hours, four days and ten days) to be of prophylactic value, though it proved to be of great curative value in three.

In Dr. Hammond's group of thirteen cases, where the drug was given prophylactically under his personal supervision, only one case became locally infected without any spread of infection and all others healed by first intention.

Our method of using sulfanilamide for prophylaxis is as follows:

1. No omission or modification of thorough surgical toilet of the wound and debridement of necrotic tissue is to be countenanced.

2. Early and adequate reduction and splinting of the fracture are as important as ever.

3. Antitetanus serum with or without supplemental sera is to be given.

4. A large initial dose of sulfanilamide—60 to 80 gr.—with equal quantity of sodium bicarbonate is to be given as soon as possible. Oral administration is preferred, otherwise hypodermoclysis or stomach tube in anesthetized patients after lavage, is used.

5. Subsequent doses are of 10-20 gr. every four hours, given with soda bicarbonate, for three to ten days.

6. A daily check is made by Marshall colorimetric test of blood sulfanilamide level to assure maintenance of effective level at the lowest dosage. A level of 5 to 8 mg. per 100 c. c. is sufficient for prophylactic effect.

7. Quicker absorption is obtained in initial dose from crushed rather than whole commercial tablets. The tablets can be chewed or given powdered in capsules or in suspension by stomach tube.

#### CONCLUSIONS

1. Chemotherapy compliments but does not replace in any way sound and necessary surgical procedures in compound fractures.

2. Sulfanilamide when used under proper control is a safe and effective drug for prevention of streptococcus and gas bacillus infections in compound fractures.

3. Failures observed in consultation have been due to inadequate dosage or improper administration with failure to

raise the blood concentration to effective level.

4. Sulfanilamide is as essential to the proper modern care of compound fractures as antitetanus serum, and is without appreciable danger.

5. It should also be used preoperatively and postoperatively in late plastic operations on old, ununited fractures which have been the site of infection.

6. Sulfanilamide is a necessary addition to the established essentials of fracture treatment: splinting, surgery, serum and sulfanilamide.

#### CASE REPORTS

CASE I. G. B. F., 23 years of age, was seen February 6, 1938 because of a severe compound comminuted fracture of the left tibia and fibula, with skin destruction and much soft part damage, severe cerebral concussion, a crush fracture of the second lumbar vertebra, a Pott's fracture of the right ankle. He was in extreme shock, and suffered from hemorrhage and multiple lacerations.

Immediate toilet and debridement of the left tibia and fibula were followed by splinting and transfusion. Antitetanus and perfringens sera were given.

A fulminating *B. welchii* and mixed streptococcus and saprophytic infection of the left leg developed on the following day. Open reduction of the fracture was undertaken, with further removal of bone fragments and necrotic soft tissue. On February 8, prontosil was given by hypodermoclysis in three doses of 5, 3, and 3 Gm. Two additional doses of 2.5 Gm. each were administered the following day. Then, from February 10 to 14, prontylin (the oral form), 0.25 Gm., was given every four hours. Culture was still positive for *B. welchii* on February 14, but the wound appeared clean and was granulating healthily.

The further course was complicated by the head and spine injuries and by a phlebitis which followed the abrasion and infection of the right ankle. However, the compound wound continued to be clean and healed astonishingly well without further bone or soft tissue necrosis.

CASE II. F. K., 21 years of age, had a compound fracture of the right tibia and fibula, resulting from a fall from a motorcycle on December 25, 1938. After x-ray and splinting

which were carried out immediately, and the administration of 1500 units of antitetanus serum and 4000 units of perfringens serum, operation was done. After toilet and careful debridement, the wound was closed and Steinmann pins and Zimmer traction were applied. Glucose was given, but no sulfanilamide, because a substitute intern did not understand the routine.

On December 27, fulminating gas gangrene had caused necrosis of the leg from the calf down. Mid-thigh amputation was done and during the next thirty-six hours 8 Gm. of sulfanilamide were given. Three blood transfusions were administered in the same period. The blood sulfanilamide on the following day was 4 mg. per cent. The amputation wound was clean and the patient afebrile. On January 7, 1939 he was discharged to the United States Army Hospital.

CASE III. M. H., 18 years old, fell from a horse on November 1, 1937, sustaining a compound fracture of the tibia and fibula. The tibia pierced the boot and stuck  $1\frac{1}{4}$  inches into the soil.

Sulfanilamide was given prophylactically on admission. Toilet, debridement and reduction were carried out and the limb was put up in a Thomas splint with pin traction. Positive smears and cultures for *B. welchii* were obtained the following day. The wound looked dirty and there was further sloughing of skin and exposed soft tissue, although no deep extension of infection was noted. The patient was practically afebrile. On November 4, there was further removal of loose bone fragments. Sulfanilamide was continued. By November 18, the wound was granulating, the skin edges could be drawn together with S.W.G. sutures to cover the large, soft tissue and bone defect. On December 20, the patient was discharged, with the leg in a windowed cast.

He was readmitted because of nonunion of the tibia on November 6, 1938. A plastic operation was done on the scar to improve the site for a later bone graft. In the healed scar, at a depth of 1.5 cm., a buried heavy S.W.G. suture was found, together with several small bone fragments and granulation tissue. Sulfanilamide was given postoperatively. Healing occurred by first intention.

On January 20, 1939 the patient was again admitted for bone grafting. Sulfanilamide was given prophylactically (1 gr.) and a sliding bone

graft was done. The drug was continued post-operatively in doses of 15, 10 and 5 gr. three times daily for three days. The patient was discharged February 11, 1939. The wound healed soundly without infection, despite the formation of a sterile hematoma in the scar.

CASE IV. H. A., 62 years old, was hit by an auto at 10 P.M. on November 17, 1938, sustaining a compound comminuted fracture of the left tibia and fibula, a comminuted intertrochanteric fracture of the right hip and a compound fracture of the right tibia. At 1 A.M. toilet, debridement and reduction of the left leg were done, followed by the application of a cast. Kirschner wire traction was used for the right hip. The right femur was splinted. Transfusion, antitetanus and perfringens sera were given. Protosil, gr. 60, was administered, followed by prontosil, gr. 10, every four hours day and night for the next three days.

The wounds healed without infection despite the extreme contamination and extensive soft tissue damage. On January 13, 1939 the patient was discharged, with his right hip in a spica and the left leg in a cast.

#### EASTON HOSPITAL CASES

CASE I. (November 1, 1937.) Compound fracture of tibia and fibula. Tibia stuck through boot and imbedded in soil. Drug administered on admission. Positive smears and cultures for Welch bacilli in twenty-four hours, but no extension above fractured site.

CASE II. (November 18, 1937.) Gunshot wound. Compound fractures of metacarpals. Drug administered on admission. No infection; healed rapidly. Good result.

CASE III. (December 13, 1937.) Compound comminuted fractures of both tibia and fibula. Fragments projecting through clothing. In contact with street. Many small particles of debris from road clinging to bone. Drug administered on admission; wound closed. No drains. Steinmann pins above and below fractures. No infection. Result good.

CASE IV. (December 13, 1937.) Compound fracture of femur, result of gunshot wound. Drug administered on admission. Wound healed by first intention. Result good.

CASE V. (January 28, 1938.) Gunshot wound of elbow. Drug administered on admis-

sion. Healed promptly with no osteomyelitis. Elbow motion limited to about 75 per cent normal.

CASE VI. (April 17, 1938.) Compound fractures of tibia and fibula with extensive trauma to the soft tissues. Hit by automobile which was traveling at excessive speed. Fractured surfaces in contact with road. Wound closed without drains. Drug administered on admission. Healed by first intention. No osteomyelitis. Steinmann pins above and below fractures.

CASE VII. (May 18, 1938.) Compound fracture of tibia and fibula. Bones were in contact with farm soil. Drug administered on admission. Wound closed and healed without infection. Result good.

CASE VIII. (August 2, 1938.) Compound fracture of radius and ulna. Farm injury. Drug administered on admission. Wound closed and healed without infection. Result good.

CASE IX. (September 7, 1938.) Compound fracture tibia and fibula. Waterman. No known contact with soil, but extensive soft tissue trauma. Wound closed. Healed without drainage. Drug administered on admission. Union not strong enough for weight bearing until five months after injury. Result good.

CASE X. (September 18, 1938.) Compound fracture of elbow with severe comminution and soft tissue injury requiring much more than the usual debridement before closing the wound. Drug administered on admission. Wound healed without infection, but the elbow has a limited motion due to the destruction of all the articular surfaces.

CASE XI. (November 25, 1938.) Compound comminuted fracture of tibia and fibula. Highway injury. Wound closed without drainage. Drug administered on admission. Wound healed by first intention. Result good.

CASE XII. (March 18, 1939.) Compound fracture of tibia, resulting from gunshot wound. Drug administered on admission. Healing by first intention. Result good.

CASE XIII. (April 5, 1939.) Compound comminuted metatarsals. Farm injury, foot run over by tractor wheel with foot imbedded in the soil. Drug administered on admission. No gas infection. Considerable sloughing of soft tissue. Still under treatment. Now healed.

# The American Journal of Surgery

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A PRACTICAL JOURNAL BUILT ON MERIT

## EDITORIAL

### WHEN?

PHYSICIANS are human beings and citizens of our United States and most of them have many questions that persist in the front of their minds—questions that call for answers.

We know only what our leaders through the press tell us. We know England and her navy is the last of the Allied defense; and we know, as we write this, that an attack on England is expected any minute. Should England be invaded or fall apart, as France did, will we be put on the spot? Is it true we are far from prepared? Could a strong foreign power with a navy prove an actual menace? When we are told we are in danger, does it mean *now*, *two months* from now or *three years* from now? If the real danger is right around the corner, must we wait ten months to begin the production of air-planes, two or three years to properly train twenty-five thousand aviators, four or five years to complete present navy contracts? Is it true it will take a couple of years to manufacture sufficient rifles to supply an army of less than half a million men? And how long will it take to make sufficient anti-aircraft guns, large tanks and the thousand other things that spell preparedness?

Is it true that early in the war Canada found herself in a bottle-neck regarding aviation because of insufficient numbers of physicians who knew the medical tech-

nique of examining applicants for the flying service? If true, how about this country? Have we enough physicians who have been trained in this work? If not, why not? War calls for expert knowledge in many of the medical and surgical branches. This was learned in the last great war. Are the medical schools making plans for undergraduate and postgraduate instruction in these specialties and fields? To date we have not heard of any move in this direction. On one hand we are told the government has every physician classified and indexed and at a moment's notice can assign him for the role he is to play; on the other hand we hear the rumor that the American Medical Association will be the headquarters and it will notify the various State organizations and through them the County societies which will fill the necessary quota of physicians. What are the true facts?

If we are in peril, why do we not take off our coats, roll up our sleeves and get to work? This means the ditch digger, the mechanic, the specialist and the doctor of medicine. Why at this time a six-hour day and a five-day week? France had that and see where she got the axe.

When are we going to stop talking and get to work—the day after a war has formally been declared? France and Eng-

land, poorly led and ill prepared turned to us and cried for help. Should our turn come, to whom can we apply? What nation deep in its heart loves us sufficiently to

make the supreme sacrifice for us? You know the answer . . . but when will we get going . . . when?

T. S. W.



## JOURNAL OF THE NATIONAL CANCER INSTITUTE

THE National Cancer Institute, of the National Institute of Health, United States Public Health Service, announces the forthcoming issue of *The Journal of the National Cancer Institute*, the official organ of the Institute.

The new journal, to be issued bimonthly, will be of the scientific type of periodical and will contain articles by the members of the staff on the various lines of cancer research work carried on by the Institute.

The first issue will contain papers on the Federal cancer control program, approaches to cancer research, effect of various hydrocarbons in producing tumors

in mice and studies on normal and cancerous tissues.

Copies of the journal will be sold to applicants by the Superintendent of Documents, Government Printing Office, Washington, D. C., who will also handle all annual paid subscriptions. The journal will be distributed free to a limited number of medical schools, to workers in the field of cancer research, research institutes interested in cancer, to a limited number of surgeons, as well as to certain Government depositories, and to journals making suitable exchanges.

# ORIGINAL ARTICLES

## CERVICAL SPINE TRAUMA ASSOCIATED WITH INJURY OF THE HEAD AND SHOULDER GIRDLE: COLEMAN'S SYNDROME\*

J. M. MEREDITH, M.D.

AND

EVERETT GRANTHAM, M.D.

Assistant Clinical Professor of Neurosurgery,  
University of Virginia School of Medicine

University of Louisville School of Medicine

UNIVERSITY, VIRGINIA

LOUISVILLE, KENTUCKY

A NUMBER of years ago it was emphasized by Dr. C. C. Coleman that if the head and a shoulder are traumatized simultaneously, the cervical spine must often sustain forces acting in opposite directions and is very likely to be injured where the two forces converge. A natural result of this observation was greater vigilance in searching for a possible injury of the cervical spine when the examination disclosed a combined injury to the head and shoulder girdle. This combination of injuries was found so frequently in the Clinics that it has come to be known among the resident staff as Coleman's syndrome.

It is of great importance that a systematic examination of the entire body, as soon as the general condition of the patient permits, be made routinely when a head injury is present. Disturbance of consciousness from a head injury often makes it difficult to recognize important associated injuries in other regions of the body. The delayed recognition of injuries of the chest, spine and long bones may result in serious consequences to patients with head trauma, which latter lesion, in many cases, may not be severe enough to threaten the patient's life.

The associated cervical spine injury is especially apt to be overlooked: (1) when

there is no evidence of trauma to the spinal cord, such as would be indicated by paralysis or bladder disturbance; (2) in an unconscious patient who has obvious signs of a shoulder girdle injury, such as a fractured clavicle, but is unable to coöperate in a general examination; (3) in a patient with bloody spinal fluid from intracranial injury. In the last group of cases the rigidity of a broken neck is often erroneously attributed to subarachnoid hemorrhage from the head trauma until x-ray examination of the cervical spine shows the true cause.

The importance of this combination of injuries should be emphasized. Injury to the cervical spine should be suspected at the scene of the accident, if a combined head and shoulder injury is discovered by the physician, so that the cervical spine may be immobilized en route to the hospital. Furthermore, at the hospital, similar precautions should be observed immediately for the protection of the cervical spine until clinical and Roentgen examinations, including a film through the open mouth to permit inspection of the odontoid process of the axis and the atlas-axis relationship, have definitely excluded cervical spine injury. The associated head injury is of no specific type. It may be a simple

\* From the Departments of Neurological Surgery, University of Virginia, and The Medical College of Virginia, Dr. C. C. Coleman, Director.

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concussion with or without a skull fracture. The shoulder girdle injury may be a fracture of the clavicle, acromioclavicular



FIG. 1. Case 1. Complete fracture through the base of the odontoid process (arrow) which is slightly separated from the body of the axis (open mouth view).

separation, fracture of the scapula, upper end of the humerus, or a severe contusion of the shoulder. When one of these injuries to the shoulder girdle or upper humerus is found combined with head trauma, x-ray examination of the cervical spine should be done as soon as the patient's general condition permits.

The following six cases, chosen from a large number of similar ones treated in the Departments of Neurological Surgery at the University of Virginia and at the Medical College of Virginia during the last three years, emphasize the salient features of the syndrome:

**CASE I.** A white male, 23 years of age, was admitted to the University of Virginia Hospital, September 22, 1938 and discharged improved five days later.

On the day of admission he had fallen from a tree and was unconscious for a few minutes. He also had pain in the right shoulder and in the

upper cervical spine. The patient was conscious and rational and there were no signs of spinal cord injury. An acromioclavicular strain on the right side was diagnosed by the Orthopedic Department. Skull plates showed no fracture. X-ray of the cervical spine demonstrated a complete fracture through the base of the odontoid process which was slightly separated from the body of the axis. The neck was immobilized in a Thomas collar and covered with a plaster cast.\*

*Comment.* This case demonstrated the value of the open mouth x-ray plate in investigation of cervical spine injuries; the ordinary anteroposterior and lateral views disclosed no abnormality. Immobilization must be maintained for several months as union of an odontoid fracture is usually fibrous rather than a true bony repair.

**CASE II.** A white male, 28 years of age, was admitted to the Medical College of Virginia Hospital March 28, 1936 and discharged improved April 13, 1936.

The patient was brought to the emergency room immediately after an automobile accident in which he had been rendered unconscious for ten minutes. There was pain in the left shoulder and swelling in the neck posteriorly.

X-ray examination of the skull was negative for fracture. There was a comminuted fracture of the greater tuberosity of the left humerus. Films of the cervical spine disclosed comminuted fractures of the spinous processes of the second and third cervical vertebrae.

The patient was discharged sixteen days after admission in good condition (except for aphasia due to contusion of the left cerebral hemisphere), a plaster collar having been applied to his neck.

**CASE III.** A white male, 53 years of age, was admitted to the University of Virginia Hospital December 11, 1937 and discharged improved January 7, 1938.

The patient was unconscious for one-half hour following an automobile accident and when he regained consciousness was unable to move the right leg. Examination disclosed a Brown-Séquard syndrome with the sensory

\* The writers wish to acknowledge the cooperation of the Departments of Orthopedics and Radiology at the University of Virginia and the Medical College of Virginia.

level at T<sub>2</sub> dermatome on the left side. Both arms were weak when extended at the elbow against resistance. X-ray examination dis-

As the patient's condition was good, skull tongs\* were applied on the day of admission and effectively reduced the disalignment; all



FIG. 2. Case 11. Comminuted fractures of the spinous processes of the second and third cervical vertebrae (arrows). Lateral view of cervical spine.

closed no fracture of the skull but did demonstrate a fracture of the left clavicle. Films of the cervical spine demonstrated extensive injury. A small chip of bone was detached from the left dorsal border of the body of the fourth cervical vertebra. The articular processes of the third and fourth vertebrae on the left side were crushed together, as were also the left articular processes between the fifth, sixth, and seventh vertebra. The right articular process of the sixth vertebra was displaced to the left almost 0.5 cm. and the body of the sixth cervical vertebra was crushed.

The Queckenstedt test on the day of admission showed a slight subarachnoid block; the spinal fluid was clear and colorless.

weights were removed six days later. Roentgen examination showed almost complete reduction of the injury with the exception of very slight forward dislocation of the sixth on the seventh cervical vertebra. A plaster cast, applied while traction was maintained, was worn for several months.

At the time of discharge the patient's general condition was excellent, the Brown-Séquard syndrome having almost completely

\* The principle of skeletal skull traction for reduction of dislocations of the cervical spine was conceived by Dr. Coleman in 1932. An ingenious apparatus was devised by Dr. W. G. Crutchfield<sup>1</sup> of these Departments and has been used with great satisfaction in a large number of cases.



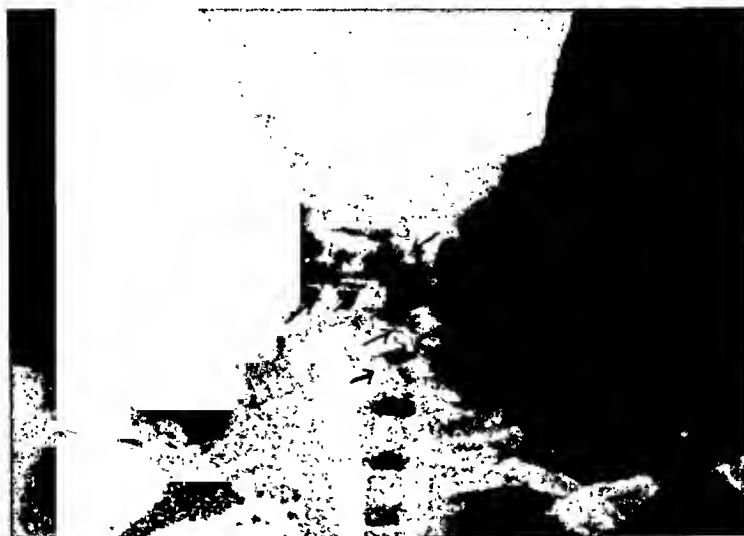


FIG. 3. Case III. Multiple fractures and crushing of greater part of the entire cervical spine (arrows). Anteroposterior view of cervical spine.



FIG. 4. Case IV. Slight dislocation of C<sub>2,3</sub> vertebrae (arrow) before reduction with skull tongs traction. It is possible to have only dislocation of the cervical spine (without fracture). Lateral view of cervical spine.

disappeared. There was slight numbness of the ulnar surface of the left forearm and hand.

*Comment.* The skeletal traction appara-

CASE IV. A white male, 18 years of age, was admitted to the Medical College of Virginia Hospital September 25, 1935 and discharged improved November 9, 1935.

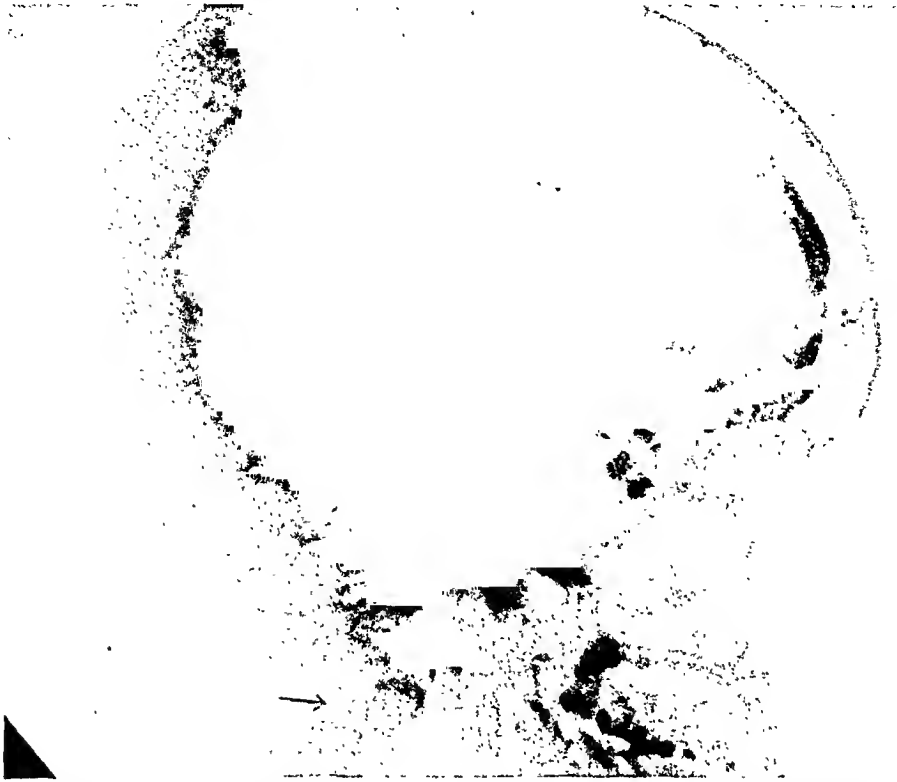


FIG. 5. Case v. Complete fracture through the lamina of the second cervical vertebra (arrow). A suggestive (slight) compression fracture of C<sub>3</sub> vertebral body was also demonstrated. Lateral view of upper cervical spine.

tus has practically eliminated the need for laminectomy in incomplete cervical cord injuries except in those cases that have stationary or advancing neurologic signs after the dislocation has been reduced by traction and in whom the Queckenstedt test still shows an incomplete or complete subarachnoid block.<sup>2</sup> Cases with a Brown-Séquard syndrome (as in Case III) due to cervical cord injury and a demonstrable dislocation can almost invariably be managed solely and effectively by the skeletal (skull) traction apparatus if treated within the first few days of the injury. Open operation in cases of immediate complete cord injury, at whatever level, is usually futile; skull traction is useful in immediate complete cord lesions in the cervical region (if dislocation is present) as root pains in the arms are usually greatly relieved, although the cord injury itself remains unaffected, as a rule,

He was admitted a few minutes after having been injured in a motorcycle accident; he remained unconscious for twenty minutes. There was bloody spinal fluid leaking from the right ear and he complained of pain in the right shoulder. X-rays on the day of admission showed a fracture of the right malar bone and of the mandible; there was a distinct widening of the right acromioclavicular joint. The day after admission he complained of pain in the cervical region for the first time and x-ray examination disclosed anterior dislocation (0.5 cm.) of the second on the third cervical vertebra. The Queckenstedt test was normal. Skull tongs were inserted and the dislocation effectively reduced, the weights being removed one week later. A plaster cast was applied and the patient discharged in excellent condition; no signs of spinal cord injury were ever demonstrated.

*Comment.* It is possible to have dislocation of the cervical spine without fracture; in the dorsal-lumbar spine, fracture almost

invariably accompanies dislocation. It is most important to detect a cervical spine dislocation at the time of the injury as



FIG. 6. Case VI. An oblique fracture through the left lamina of the seventh cervical vertebra (arrow) without involvement of the neural arch. Lateral oblique view of cervical spine. The ordinary anteroposterior and lateral views of the cervical spine were normal. In suspected traumatic lesions (especially) of the cervical spine it is important to take five different views: (1) anteroposterior view through the open mouth to demonstrate atlas-axis relationships; (2) anteroposterior view of cervical spine; (3) lateral view of cervical spine, of chief value in demonstrating dislocations and spinous process fractures; (4) and (5) right and left oblique views especially to demonstrate laminal fractures.

reduction by skull tongs or by any other method is difficult after several weeks have elapsed from the time of the injury. In the meantime, the luxation may have increased with resultant cord compression.

**CASE V.** A white female, 31 years of age, was admitted to the Medical College of Virginia Hospital August 25, 1936 and discharged improved October 26, 1936.

She was injured in an automobile accident and was still unconscious on admission, one hour or more after the injury, and remained

so for several days thereafter. On admission, the diagnosis was cerebral concussion and contusion, lacerations of the scalp and the left leg. Two days later, after the patient regained consciousness, extensive Roentgen examination disclosed a linear fracture of the right frontal bone, a comminuted fracture of the left clavicle and an oblique fracture in the body of the left scapula. There was a complete fracture through the lamina of the second cervical vertebra and suggestive fractures of the left transverse process of the second cervical vertebra and of the body of the seventh cervical vertebra.

The patient remained in the hospital for two months and no treatment of the cervical spine injury—other than immobilization with a Thomas collar—was necessary. There was no spinal cord injury.

**CASE VI.** A white male, 55 years of age, was admitted to the University of Virginia Hospital August 22, 1938 and discharged improved September 16, 1938.

On admission, on the day of injury in an automobile accident, he was in a semiconscious state, disoriented and irrational. There were multiple lacerations of the scalp and of the lower extremities. The lacerations were debrided and repaired on admission and healed per primam. Several days later, after the state of consciousness had improved, he complained of severe pain in the left shoulder which was severely contused. X-ray examination of the skull disclosed multiple linear fracture lines. There was little or no pain in the cervical spine although the neck was slightly spastic on forward flexion. The patient made a fairly satisfactory recovery from the head injury and was discharged twenty-five days after the injury, still mentally retarded. He returned to the hospital for examination eleven days later and (more because of our experience in previous cases of combined head-shoulder girdle injury than because of any complaint of the patient directed to the cervical spine) films disclosed an oblique fracture through the left lamina of the seventh cervical vertebra without involvement of the neural arch. A Thomas collar was applied and the patient has since had no further difficulty. There was no spinal cord injury.

**Comment.** These two last cases (v and vi) illustrate the importance of considering the possibility of a cervical spine injury in an unconscious patient with a combined

head and shoulder girdle injury. It has led us to adopt practically routine cervical spine x-ray examination in any such patient. The spastic neck in a patient who is unconscious from a head injury is all too readily attributed to a probable intracranial (and associated spinal) subarachnoid hemorrhage. Incidentally, Figure 6 demonstrates the value of *oblique* views of the cervical spine in traumatic cases; the usual anteroposterior and lateral views were normal in appearance in this case.

#### DISCUSSION

From the six cases described it may be seen that there is nothing specific about the type of cervical spine injury occurring in association with a combined head and shoulder girdle injury. The lesion may be a fracture of the odontoid process, rotary dislocation of the atlas on the axis, fracture-dislocation of one or more of the cervical vertebrae, fracture of the transverse, spinous or articular processes. Furthermore, it is important to recall that if paralysis or other neurologic signs are present in a patient with a severe head injury and a shoulder injury, such signs may just as likely be due to a *cervical cord contusion* as to a contusion of the brain. It is particularly easy to overlook a cervical spine injury if there is no neurologic involvement (which may, however, develop later if immediate treatment is not instituted) and if the patient complains a great

deal of the head or shoulder injury and little or not at all of the neck injury. This occasionally occurs, as shown in Case vi; here the patient's irrational state precluded his complaining of the neck injury for several weeks—even when he became rational, he complained very little of his neck until his attention was directed to it. Such cases have led us, as stated above, to conclude that in all patients with a combined head-shoulder girdle injury it is probably best to examine routinely the cervical spine as well for possible injury. The clinical importance of early recognition of cervical spine injury and its medicolegal significance require no comment.

#### CONCLUSIONS

A new post-traumatic syndrome—named after the neurosurgeon who first observed and emphasized its occurrence and frequency—is described, together with six illustrative cases. This syndrome consists of a cervical spine injury as a frequent (often unsuspected) accompaniment of a combined head-shoulder girdle injury. The importance of the early recognition of the full syndrome is stressed from various standpoints.

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# SECONDARY OSTEOARTHRITIS FOLLOWING FRACTURES OF THE ANKLE

RAYMOND W. LEWIS, M.D.

AND

WALTER C. GRAHAM, M.D.

Roentgenologist, Hospital for Ruptured and Crippled

Resident Orthopedic Surgeon, Hospital for Ruptured and Crippled

NEW YORK CITY

IT is generally accepted that following severe fractures of the ankle, there may be marked disability and pain which The loss of certain normal anatomic relations of the ankle predisposes to later changes and osteoarthritis. The main

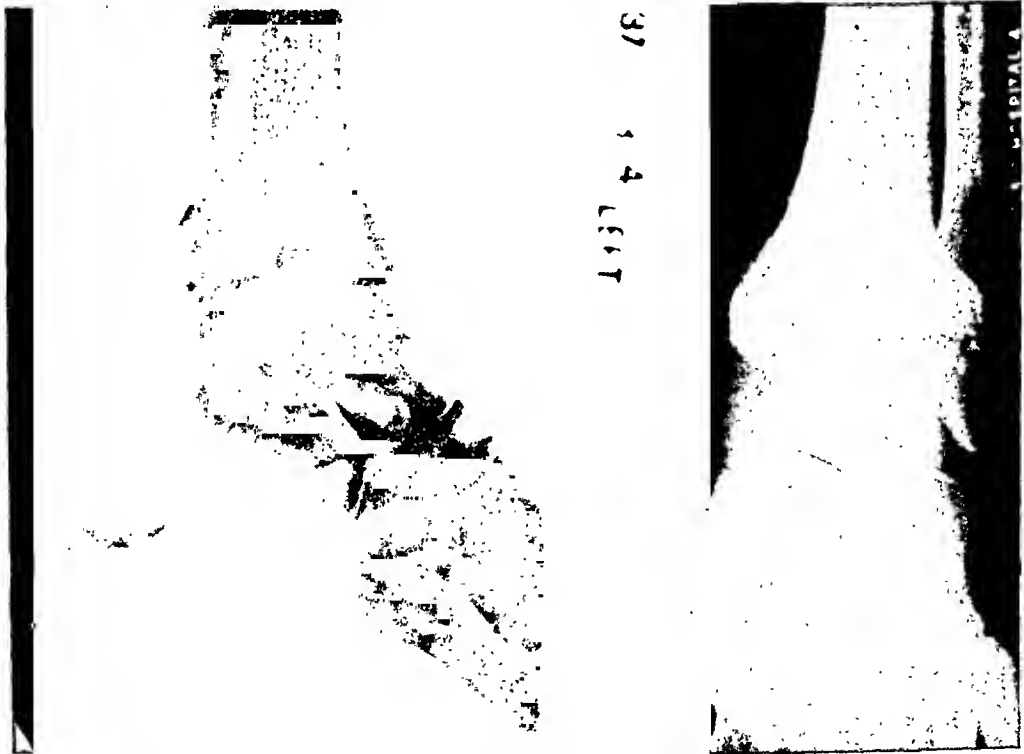


FIG. 1. W. C. Case vi. Splitting fracture. Led to osteoarthritis and fusion operation fourteen months after injury.

may develop into osteoarthritis (traumatic arthritis). Traumatic arthritis is an inflammatory condition of the joint. It may be the result of a single severe injury to the articular surface or repeated "microtraumata" from faulty posture, attitudes producing functional disability, and from unevenly distributed intra-articular pressures. It is manifested by changes in the bone, articular cartilage, synovia and capsule. The surrounding tissue shows chronic inflammation. Pain, swelling and limitation of motion are usually present.

anatomic changes resulting from fractures of the ankle are: (1) loss of the continuity of the weight-bearing surface of the tibia; (2) widening of the joint mortise; and (3) alteration of the weight bearing planes.

The age of the patient is definitely a controlling factor in determining the type of fracture sustained. Ankle fractures are infrequent under the third decade. Beekman<sup>1</sup> states that on his Children's Fracture Service at Bellevue Hospital he has never seen a Potts type of fracture. In children, the fracture is usually an inch or more

above the ankle. In Shands' series of 109 cases,<sup>2</sup> only nine were under 18 years of age. In seven of these nine, there was a

tured ankles. After the second decade, ankle fractures become quite common and almost 30 per cent of them occur in the



A



B

FIG. 2. L. P. Case XI. Good reduction of three malleolar fractures (two malleoli plus marginal), but had definite osteoarthritis for which fusion was advised two years after injury. Causative factors were probably age of 54 and slight remaining unevenness of tibial articular surface.

lower tibial epiphyseal separation with no involvement of the joint. Wilson<sup>3</sup> reports similar findings in a series of eighty frac-

third decade. The malleoli may be fractured at the level of the articular cartilage of the tibia, or the tibia-fibular ligaments

may be torn and the fibula be fractured above the joint. Involvement of the articular surface of the tibia is usually seen in older patients. Mackinnon's<sup>4</sup> and

respectively. It is evident that the more severe fractures are in the older group. It is well known that the restorative powers of the body decrease with age.



A



B

C

FIG. 3. J. A. F. Follow-up Case 11. Perfect reduction of three malleolar fractures, leaving smooth tibial articular surface. Symptom-free four and one-half years after injury, despite age of 63 years.

Wilson's<sup>3</sup> patients with marginal fractures (posterior lip of the lower tibial articulation) averaged 44.4 years and 44.6 years

Shands<sup>2</sup> and Wilson<sup>3</sup> report a higher percentage of ankle fractures in women, which, we feel, is due to the increased

strain placed on the supporting structures by higher heeled shoes. This, no doubt, accounts for the greater number of margi-

adjacent surface and produces a secondary arthritis.

The treatment of traumatic arthritis is

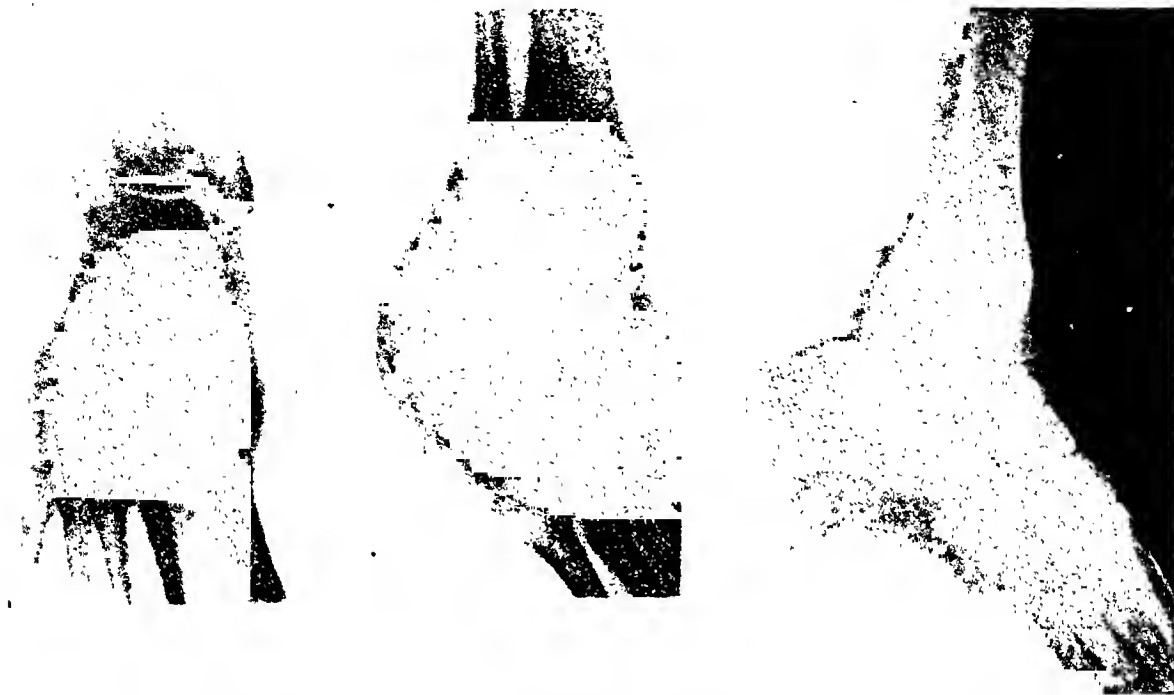


FIG. 4. S. F. Case iv. Unsatisfactory reductions of three malleolar fractures producing osteoarthritis.

nal fractures in women. Mackinnon reported sixteen cases of marginal fractures, eleven in women. Five of the women he described as being "very heavy."

The displacement of the astragalus on the tibia is seen frequently in traumatic arthritis. Shands reports it in 100 per cent of his cases of ankle fracture. If the normal relation and weight-bearing lines (as described by Skinner<sup>5</sup>) are not restored, the ankle is not reduced and may give trouble. Appelbach<sup>6</sup> reports that follow-up showed 94 per cent of his cases with an increase in the mortise. A wide joint is not stable and results in disturbed intra-articular pressure, which puts undue strain on the ligaments, capsule and cartilage.

The most frequent etiologic factor, both in our cases and in those reported in the literature, is an irregularity in the weight-bearing cartilage. This usually follows a marginal fracture, but may result from the astragalus being displaced laterally or mesially. Cartilage will not fill in these defects and produce a smooth surface.<sup>7,8,9</sup> The irregular surface destroys the smooth

primarily prevention. Fundamental preventive treatment is given at the time of reduction of the fracture. The reduction must be as nearly anatomic as possible. X-ray must show perfect reduction and restoration of joint width, especially in marginal fractures which are more often improperly reduced than are malleolar fractures. The fragment is usually displaced upward on the tibia and must be replaced to restore the continuity of the weight-bearing surface. If it is not replaced, traumatic arthritis results and fusion of the joint is called for to relieve the severe pain. Repeated attempts at closed reduction may be necessary; if they are not successful open reduction should be resorted to.

The next step in the prevention of traumatic arthritis is correcting malunited fractures before the articular cartilages have been severely damaged. The requirements in such reconstruction operations are: (1) restoration of the weight-bearing alignment; (2) restoration of the normal anatomic relationship between the articular surfaces of the tibia, fibula, and astragalus;



and (3) restoration of a satisfactory range of painless motion. If these requirements cannot be fulfilled, a fused ankle in the

uniformly poor results in reconstruction of the joint surface. A later arthrodesis was necessary in all seven of his cases.



FIG. 5. I. H. Case v. Unsatisfactory reductions of three malleolar fractures producing osteoarthritis.



FIG. 6. A. E. Case vii. Unsatisfactory reductions of three malleolar fractures producing osteoarthritis.

proper position is much more satisfactory. Speed<sup>10</sup> and Mackinnon reported poor results in attempting to reconstruct the articular surface of the tibia. They feel fusion is necessary to give a painless weight-bearing member. Wagner<sup>11</sup> reports

The present study is based on eighteen patients who had secondary osteoarthritis following ankle fractures and desired relief of persistent pain and disability. We made an unsuccessful attempt to follow up and study, as a control series, a group of

patients with fractured ankles who had not returned with complaints. We were able to induce only two such patients to return.

3. *Symptom-Free Interval.* A perhaps significant similarity in this group is that sixteen of the eighteen had no symptom-



FIG. 7. E. E. Case VIII. Unsatisfactory reductions of three malleolar fractures producing osteoarthritis.

However, certain similarities in the eighteen post-fracture osteoarthritic patients provoke interesting lines of thought.

1. *Age.* Fourteen patients were between the ages of 35 and 56—that is, they were well within the age period of osteoarthritis. In the remaining four, there were special circumstances which seemed to afford adequate explanation of the onset at earlier ages: in two there were splitting fractures of the lower extremity of the tibia, where there were uneven articular surfaces; a third had a badly comminuted fracture in which three unsuccessful attempts had been made to obtain satisfactory reduction; the fourth patient was a waitress with an ununited mesial malleolus. The average age of the entire group of eighteen was 40.

2. *Sex and Weight.* Two-thirds of these patients (twelve) were women. Of these, five were recorded as overweight, and others may well have been so without mention of the fact in the history. The significance of this sex difference in incidence may lie in less strong muscles to support an injured ankle, and perhaps aggravation of this circumstance by overweight.

free interval between the time of fracture and the time they applied for relief of osteoarthritis.

4. Two-thirds of the patients had three malleolar fractures (two malleoli plus marginal), three had splitting fractures of the lower extremity of the tibia, and only two had two malleolar fractures.

5. Judging from the position at the time of their visit to us, only three of the eighteen reductions might be classified as nearly mechanically perfect. In three others there had been splitting fractures of the tibia, which left defects and irregularities in the lower tibial articular surface. The other twelve patients showed malalignments and deformities of various degrees.

6. Fourteen patients had no reduction or one or more closed reductions; three had closed reduction followed by open; the treatment received by the remaining patient is not known to us.

7. The condition at the time of their visit to us was such as to warrant fusion operations in nine out of the eighteen, and to place fusion under consideration in six others. Of the remaining three, no decision has been reached in one; one received

# STATIS OSTEOAR

NAME, NUMBER	SEX	PRESENT AGE	WEIGHT	TIME OF INJURY	TYPE OF INJURY	TWO MALLEOLAR THREE MALLEOLAR SPLITTING	REDUCTION CLOSED OPEN
E. C. CASE 1	FEMALE	41	NOT RECORDED	10½ YEARS AGO	NOT KNOWN	THREE MALLEOLAR	CLOSED
E. O. C. CASE 2	FEMALE	43	OBESE	1 YEAR 8 MONTHS AGO	FELL ON ICE	THREE MALLEOLAR	CLOSED
H. P. CASE 3	FEMALE	36	OVERWEIGHT	3 YEARS AGO	SLIPPED ON RUG, FELL	TWO MALLEOLAR	CLOSED
J. F. CASE 4	FEMALE	35	LARGE, WELL DEVELOPED	7 MONTHS AGO	FELL ON ICE	THREE MALLEOLAR	CLOSED
I. H. CASE 5	FEMALE	50	MODERATELY OBESE	2½ YEARS AGO	STEPPING FROM AUTO	THREE MALLEOLAR	CLOSED
W. C. CASE 6	MALE	36	NOT RECORDED	14 MONTHS AGO	FELL FROM TREE	SPLITTING OF TIBIA	CLOSED
A. E. CASE 7	FEMALE	44	NOT RECORDED	5 YEARS AGO	NOT RECORDED	THREE MALLEOLAR	CLOSED
E. E. CASE 8	MALE	43	NOT RECORDED	6 MONTHS AGO	FELL AND TWISTED ANKLE	THREE MALLEOLAR	IN BED 3 WEEKS NO MENTION OF REDUCTION
F. M. CASE 9	FEMALE	48	SLIGHTLY OVERWEIGHT	3 YEARS AGO	NOT KNOWN	THREE MALLEOLAR	FIRST CLOSED THEN OPEN
M. L. CASE 10	FEMALE	42	NOT RECORDED	4 YEARS AGO	NOT KNOWN	THREE MALLEOLAR	NOT KNOWN
L. P. CASE 11	FEMALE	56	NOT RECORDED	2 YEARS AGO	FALL IN HOME	THREE MALLEOLAR	CLOSED
H. R. CASE 12	FEMALE	21	NOT RECORDED	3½ YEARS AGO	NOT KNOWN	TWO MALLEOLAR	CLOSED
S. S. CASE 13	MALE	31	NOT RECORDED	15 YEARS AGO	FELL TWO STORIES LANDING ON FEET	SPLITTING OF LOWER TIBIA	NOT REDUCED
R. J. CASE 14	FEMALE	50	NOT RECORDED	15 MONTHS AGO	SLIPPED ON ICE	TWO MALLEOLAR	CLOSED OPEN 4 MO'S LATER
J. S. CASE 15	MALE	22	NOT OVERWEIGHT	3 YEARS AGO	MOTOR ACCIDENT	TWO MALLEOLAR AND SPLITTING OF LOWER TIBIA	THREE CLOSED REDUCTIONS
A. A. CASE 16	MALE	46	NOT OVERWEIGHT	11 MONTHS AGO	FELL ON ICE	THREE MALLEOLAR	CLOSED
J. K. CASE 17	FEMALE	47	NOT RECORDED	17 MONTHS AGO	SLIPPED	THREE MALLEOLAR	CLOSED
A. P. CASE 18	MALE	28	NOT RECORDED	13 MONTHS AGO	FELL TWO STORIES TO PAVEMENT	THREE MALLEOLAR	PERMANENT, THEN CLOSED AFTER 10 DAYS OPEN 4 MO'S LATER, JERKED IN ANTERIOR MALLEOLUS
FOLLO							
L. C. CASE 1	FEMALE	51	OBESE	8 YEARS AGO	FELL DOWN STAIRS	THREE MALLEOLAR	CLOSED
J. A. F. CASE 2	MALE	68	NOT RECORDED	4½ YEARS AGO	SLIPPED ON ICE, TWISTED ANKLE	THREE MALLEOLAR	CLOSED

## TICAL CHART THRITIS CASES

ORIGINAL DEFORMITY ORIGINAL REDUCTION	INTERVAL FREE FROM SYMPTOMS	PRESENT X-RAY FINDINGS	TREATMENT INSTITUTED OR ADVISED
X-RAYS NOT SEEN	UNTIL 3 MONTHS AGO	GOOD REDUCTION EXCEPT FOR SLIGHT VARUS DEFORMITY. EVIDENCE OF FAIRLY EARLY OSTEOARTHRITIS	TO CORRECT VARUS. IF SYMPTOMS NOT RELIEVED, TO CONSIDER FUSION.
X-RAYS NOT SEEN	NONE. SWELLING AND PAIN WORSE RECENTLY	BAD REDUCTION. SPREADING OF MORTISE. BACKWARD DISPLACEMENT OF FOOT. NON- UNION OF MEDIAL MALLEOLUS. MARKED OSTEO- ARTHRITIS	FUSION PERFORMED
X-RAYS NOT SEEN	NONE	BAD REDUCTION. BACKWARD AND UP- WARD DISPLACEMENT, VALGUS. MARKED OSTEOARTHRITIS	FUSION PERFORMED
X-RAYS NOT SEEN	NONE	MODERATELY BAD REDUCTION. LATERAL DISPLACEMENT AND VALGUS. DEFINITE OSTEOARTHRITIS	NOT KNOWN
X-RAYS NOT SEEN	NONE. WORSE FAST FEW MONTHS	MODERATELY BAD REDUCTION. FOOT LATERAL AND POSTERIOR. VALGUS. SEVERE OSTEOARTHRITIS	FUSION PERFORMED
X-RAYS NOT SEEN	NONE	VERTICAL SPLITTING FRACTURES, SCITAL AND CORONAL PLATES. ANTERO-POSTERIOR AND LATERAL SPREADING. MODERATE OSTEOARTHRITIS	FUSION PERFORMED
X-RAYS NOT SEEN	NONE	BAD REDUCTION. LATERAL DISPLACE- MENT AND VALGUS. MODERATE OSTEOARTHRITIS	FUSION PERFORMED
X-RAYS NOT SEEN	NONE	BAD LATERAL DISPLACEMENT AND VALGUS. SLIGHT OSTEO- ARTHRITIS	TO TRY PHYSIO-THERAPY FOR 6 WEEKS. IF NOT RELIEVED, FUSION TO BE ADVISED
X-RAYS NOT SEEN	NONE	1. BEFORE OPEN REDUCTION, SLIGHT LATERAL DIS- PLACEMENT AND VALGUS. NON-UNION OF MEDIAL MALLEOLUS. 2. AFTER OPEN REDUCTION UNION, SLIGHT LATERAL DISPLACEMENT & VALGUS. FAIRLY EARLY OSTEOARTHRITIS	STILL UNDER OBSERVATION
X-RAYS NOT SEEN	PROBABLY NONE	GOOD REDUCTION. GOOD ALIGNMENT. POSSIBLY SLIGHT MORTISE SPREAD. DEFINITE OSTEOARTHRITIS	TO TRY CONSERVATIVE MEASURES
X-RAYS NOT SEEN	NONE	GOOD REDUCTION. GOOD ALIGNMENT. THIN CARTILAGES. ENORMOUS SWELLING. DEFINITE OSTEOARTHRITIS	CONSERVATIVE TREATMENT TO BE TRIED. ADVISED THAT ONLY REAL RELIEF WILL BE BY FUSION.
X-RAYS NOT SEEN	NONE	NEARLY GOOD REDUCTION. NON-UNION OF INTERNAL MALLEOLUS. SLIGHT OSTEO- ARTHRITIS IN ASTRAGALAR-INTERNAL MALLEOLAR ARTICULATION. SWELLING.	FUSION ADVISED BECAUSE OF FINDINGS AND BECAUSE OF OCCUPATION OF WAITRESS
NO ORIGINAL X-RAYS	3 YEARS SYMPTOMS, 2 YEARS FREE, 4 YEARS SYMPTOMS	WIDENING OF LOWER EXTREMITY OF TUBA. DEFORMITY AND ROUGHENING OF ARTICULAR SURFACE. MODERATE OSTEOARTHRITIS	TO TRY CONSERVATIVE TREATMENT. WILL PROBABLY NEED FUSION.
ORIGINAL DEFORMITY GREAT. CLOSED REDUCTION BAD. OPEN REDUCTION IM- PERFECT	NONE	MODERATE BACKWARD DISPLACEMENT OF FOOT. SLIGHT VALGUS. CARTILAGES GONE. MODERATE SCLEROSIS	FUSION ADVISED
VERY SEVERE ORIGINAL DEFORMITY	NONE	MUCH JOINT DEFORMITY. VERY BAD ALIGNMENT. ROUGH AND OBLIQUELY PLACED ARTICULAR SURFACES	FUSED
SEVERE ORIGINAL DEFORMITY	NONE	BAD REDUCTION. MARKED LATERAL DISPLACEMENT OF LOWER FRAGMENTS AND FOOT. MARKED VALGUS. THIN CARTILAGES.	FUSED
SEVERE ORIGINAL DEFORMITY	NONE	BAD REDUCTION. LATERAL DISPLACE- MENT OF LOWER FRAGMENTS AND FOOT. BACKWARD DISPLACEMENT OF FOOT. DEFINITE OSTEOARTHRITIS	FUSED
X-RAYS NOT SEEN	NONE	MARKED VARUS DEFORMITY. SCREW IN INTERNAL MALLEOLUS. PROBABLY UNION. MUCH OSTEOARTHRITIS	FUSED
<b>W-UP CASES</b>			
SEVERE ORIGINAL DEFORMITY. EXCELLENT REDUCTION		GOOD UNION. GOOD ALIGNMENT. SLIGHT THINNING OF CARTILAGES LATERALLY	COMMENT: GOOD RESULT. SOME PAIN IN ANKLE WITH CHANGE IN WEATHER. SOME PAIN AND SWELLING WITH PROLONGED USAGE
VERY SEVERE DEFORMITY. EXCELLENT REDUCTION.	PAST 3 YEARS	GOOD UNION. GOOD ALIGNMENT. NO OSTEOARTHRITIS	COMMENT: EXCELLENT RESULT. NO SYMPTOMS. PAST THREE YEARS AS GOOD AS OTHER ANKLE—

conservative treatment; the treatment of the third is not known.

8. Thirteen of the patients applied for relief of disability from six months to three years following fracture. Analysis of the remaining five (who came in three and one-half to fifteen years after fracture) on the basis of age at the time of injury and perfection of reduction, is interesting. (Table 1.)

TABLE 1

		Age at Injury	Interval since Fracture, Years	Reduction	Possible Explanation of Interval
H. R.	Case XII	18	3½	Bad; non-union of internal malleolus	Youth at time of injury
M. L.	Case X	38	4	Good	Good reduction
A. E.	Case VII	39	5	Bad	None
E. C.	Case I	30	10½	Good	Good reduction, comparative youth
S. S.	Case XIII	16	15	Bad splitting fracture	Youth at time of injury

Only one of these cases with interval longer than three years is not susceptible of explanation on either the grounds of unusual youth or unusually good reduction.

In further consideration of age as a factor, it may be noted that two of the three cases we classified as having a nearly mechanically perfect reduction were in the above group, M. L. and E. C. The age of the third, L. P., Case XI, who applied to the hospital for relief two years after her fracture, is a likely explanation for her non-appearance in the more delayed group. She was the oldest patient in this series, and was 54 at the time of her fracture.

#### SUMMARY AND CONCLUSIONS

Although conclusions are unwarranted in such a small series of cases, several interesting possibilities are suggested, which

time and further experience may establish as facts.

1. Age, sex, and probably weight appear to be definite factors in the occurrence of these fractures and in determination of their outcome.

2. Protracted symptoms over a period of months following treatment constitute a very unfavorable sign.

3. Three malleolar fractures and splitting fractures of the lower extremity of the tibia seem more prone to lead to secondary osteo-arthritis than fractures of one or two malleoli.

4. Nothing short of mechanically perfect reduction affords a reasonable chance of avoiding secondary osteoarthritis, and even then there is no positive assurance of escape.

5. Perfect reduction will sometimes bring excellent results, even when all other factors are unfavorable, as shown by our two follow-up cases. Between them, these two cases embodied all the unfavorable features: age (63 and 43), sex, obesity, three malleolar fractures with severe original deformities, symptoms persisting for one and a half years after injury. They had perfect closed reductions, and showed excellent end results four and a half and eight years after injury.

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# ACTIVE MUSCLE USAGE IN THE TREATMENT OF FRACTURES

OTHO C. HUDSON, M.D., F.A.C.S.

Chief of Orthopedic Surgery, Meadowbrook Hospital

HEMPSTEAD, NEW YORK

**I**N the treatment of fractures proper reduction of the lesion, immobilization until union occurs, and restoration of the function of the extremity are recognized necessities. It is also generally accepted that the optimum time for reduction of a fracture is as soon as possible after the accident. At this time contractures are not present, the tissues are not indurated, and swelling is not extensive. The reduction is accomplished by the use of manipulation, traction, gadgets, or open operation. The permanent immobilization is immediately applied whether it be plaster of Paris in any form, or skeletal traction in splints or plaster of Paris.

The object of this paper is to present some facts not given sufficient attention in the treatment of fractures. We were taught in school to immobilize a fracture, and to keep the muscles quiet. This treatment quickly leads to stiff joints, swelling of the extremity and a convalescence prolonged long after the bony injury has healed. This teaching is fallacious. During the entire time of immobilization of the fracture, active motion of all joints not immobilized and muscle contraction of those beneath the fixation dressing prevent joint stiffness and swelling.

To secure active joint motion of un-immobilized joints the fracture must be adequately fixed so as not to cause pain. If this is not done, any attempt to move the joints causes pain and muscle spasm, and no motion occurs. Active contraction of all muscles under the dressings causes active relaxation in their antagonists, the tonicity of these muscles is maintained, and the minimum amount of atrophy occurs. Active usage is of prime importance

during the fixation period of healing. This principle is not sufficiently stressed.

How many times have you seen a frozen shoulder following a Colles' fracture, or after some trivial accident to the elbow?

How many times have you seen stiff fingers and a swollen hand following a Colles' fracture?

How many times have you seen extreme atrophy of the quadriceps following a fracture of the patella?

How many times have you seen contracted toes and an acute anterior metatarsalgia following fracture of the metatarsals?

The cause of each of these complications is lack of active muscle usage. These disabling sequelae can be prevented.

Every patient should actively move joints which are not immobilized and contract the muscles under the dressings from ten to twenty times or for ten minutes every hour on the hour during the entire waking day beginning the day of the injury and continuing until the fracture is healed. This simple rule will prevent these stiff joints and swollen extremities that take months to rehabilitate.

In injuries to the phalanges and metacarpals adequate fixation of the involved fingers only is needed and active use of all others is permitted.

In Colles' fractures, fractures of both bones of the forearm, and other fractures of the radius or ulna, the immobilization extends from just proximal to the distal palmar crease to the axilla. Complete active motion of all the fingers and shoulder is done hourly, together with biceps contraction. This active use keeps down swelling and keeps the muscle-tendon sense normal. Joint stiffness then will not occur

in the fixed joints. The fracture must be kept adequately immobilized to prevent pain, for this prevents active usage.

The same activity is insisted upon even when a shoulder spica has been applied.

In the lower extremities, active toe motion and quadriceps exercises hourly will keep the muscle-tendon sense normal, prevent atrophy of the muscles, and prevent joint stiffness.

No passive motion or any other form of physiotherapy will then be needed. After complete healing of the fracture and re-

moval of all fixation, joint function returns rapidly and completely with a few hot soaks in the bathtub.

Immediately on removal of the fixation apparatus after this régime, active motion in the immobilized joints through 30 to 40 degrees of painless motion is possible.

#### SUMMARY

This paper stresses the importance of active muscle and joint usage in the treatment of fractures neglecting other forms of physiotherapy.



OCCUPATIONAL therapy is almost essential in the care of the convalescent orthopedic patient. These patients are often in good general health, vigorous, alert, and restless, and their physical disability, which may be confined to a portion of one extremity, is likely to become irksome. From—"Convalescent Care" (New York Academy of Medicine).

# TUMORS RELATED TO CARTILAGINOUS GROWTH

HARVEY L. LLOYD, M.D.

First Lieutenant, Medical Corps, U. S. Army

BROWNSVILLE, TEXAS

IT is the growing opinion of many that neoplasia is a mechanism transmitted as a recessive character by heredity, fixed in the tissues to come in bloom at a certain period of the individual's development if the individual survives. The group of bone tumors reported here serve as excellent illustrations of this theory. It is believed that any other group of malignancies might exhibit similar truisms if classified according to their embryonic anlagen.

## *Taxonomy of Bone Tumors:*

- i. Tumors related to cartilaginous growth:
  - Bone cysts
  - Giant cell tumor
  - Osteolytic sarcoma.
- ii. Tumors related to precartilaginous growth:
  - Osteogenic sarcoma
  - Chondroma
  - Osteochondroma.
- iii. Tumors not primarily of osseous origin:
  - Ewing's tumor
  - Multiple myeloma
  - Metastatic carcinoma
  - Fibrosarcoma.

This classification<sup>1</sup> and most of the ideas presented in this paper are based on the work of Bloodgood, Geschickter, Cope-land,<sup>2</sup> and Nélaton.<sup>3</sup>

*Bone Cyst.* The clinical features of bone cyst as manifested in the fourteen patients who received this diagnosis at the State University of Iowa are as follows:

Average age.....	13.6 years
Females.....	9
Males.....	5
Duration of symptoms.....	2.9 years
Incidence of trauma.....	7
Incidence of fracture.....	4
Pain.....	11

Tenderness.....	11
Swelling.....	11
Redness.....	3
Multiple lesions.....	5

No lesion was found in a bone that was not derived from cartilage. The characteristic features of the roentgenograms were: ununited epiphysis, metaphyseal location, central area of bone destruction crossed by trabeculation. If there had been a fracture, a dense shadow of new bone was seen. The shell was not perforated except by fracture or surgery and its thickness varied inversely with the duration of symptoms. There was a fibrous tissue lining and the contents might be fluid, fibrous, grumous material or an admixture of all. Fibrous trabeculation could be felt; there was multiloculation and occasionally bone spicules. Microscopically, giant cell areas were seen, areas of old hemorrhage, bone islands, and areas of fresh hemorrhage.

When a bone cyst occurs at a site where multiple centers of ossification are present, it may take on many of the characteristics of a giant cell tumor and tend to progress. Such a lesion will present multiple small cysts filled with hemorrhage and surrounded by giant cells. However, it is metaphyseal in location. Such a patient (G. B.) at age 22 complained of pain, swelling, and tenderness in the upper femur of eighteen years' duration. She responded poorly to bone graft, immobilization, and Roentgen therapy.

The line of demarcation between the single bone cyst, the giant cell variant of bone cyst, and polycystic osteitis fibrosa is by no means sharp. The histology is similar and patients may be found who are difficult to classify. In one such case (L. T.), the patient, aged 29, first complained of pain in the right hip. She was found to



have two small bone cysts in the body of the right ilium which became asymptomatic for ten years following Roentgen therapy. She was then found to have bone cysts of the fourth, fifth, sixth and seventh right ribs and a mild pleurisy. Biopsy revealed osteitis fibrosa cystica, the symptoms of which were relieved following Roentgen therapy. The blood calcium was normal.

The production of a bone cyst seems to be bound up with the activity of the giant cell. These cells may run amok when the reparative power of bone is jeopardized by a decalcifying process such as hyperparathyroidism, but when the agent that injures bone is trauma, the giant cells are allowed only a short period of activity before healing occurs and we get the simple cyst. Victims of hemophilia may bleed into bone and cause mimic osteitis fibrosa. Many cases of Paget's disease resemble the generalized type of bone cyst; the common factor is the giant cell.

*Giant Cell Tumor.* The clinical features of giant cell tumor as manifested in the twenty-two cases in which this diagnosis was made at the State University are as follows:

Average age.....	28 years
Females.....	11
Males.....	11
Duration of symptoms.....	16 months
Incidence of trauma.....	15
Incidence of fracture.....	13
Pain.....	20
Tenderness.....	21
Redness.....	4
Multiple lesions.....	1

The characteristic x-ray features were asymmetrical location in the epiphysis, osteolysis and expansion centrally at the expense of cancellous bone. Trabeculation was seen, but there was no periosteal reaction. The fibrous tissue lining resembled that of bone cysts and the contents were usually hemorrhagic, oozing blood, friable and fibrous trabeculations. Bone spicules were palpable. Microscopically there were large masses of giant cells in a mass of smaller round cells. The giant cells

were more numerous about areas of old hemorrhage, spicules of bone and cyst walls. The nuclei of the round cells had the same morphology and staining characteristics as the nuclei of the giant cells. Spindle cells indicated a healing reaction. Some giant cell tumors are practically indistinguishable from osteitis fibrosa cystica because of this fact. The lesions occurred in bones where the anatomic structure was unusually prominent. As an example, we may cite the case of a patient who at 59 presented a giant cell tumor of the phalanx which had been present forty-four years as a sequel to a baseball injury.

Bloodgood, Geschickter and Copeland hold that these lesions can arise only from bone derived from cartilage. Two of the patients of this series had giant cell tumor of the skull, one of which was located at the angle of the mandible, a frequent site, and the other was said to be in the maxilla, a bone formed in membrane. However, a description of the lesion, as given in detail at the time of operation, located the tumor in the roof of the nose and the antrum. A similar problem had confronted the above authors, whose case involved the antrum and orbit. Their argument was that the ethmoid, which is derived from cartilage, might well be the source of the neoplasm since the lamina papyracea forms the medial wall of the orbit and the uncinate process overlies the maxillary ostium. Curiously enough we have seen two patients with osteitis fibrosa cystica of the skull and each had a lesion at the angle of the jaw and another lesion in the ethmoid, one presenting a visible swelling just to the right of the nose and another at the nasion. Nélaton presents beautifully hand drawn pictures of giant cell tumors, one of them limited to the ethmoid bone.

Giant cell tumor is occasionally found in the vertebrae and may then cause symptoms of cord compression. Lewis<sup>4</sup> has noted that such lesions are of the spindle cell variety and have a tendency to heal on their own, some patients having gone on to healing subsequent to curettage of a large

part of the tumor. A fusion operation may follow.

When a giant cell tumor is present

cartilage, the odontoclasts comparable to osteoclasts, multinucleated, and serving the same purpose in absorbing the mem-

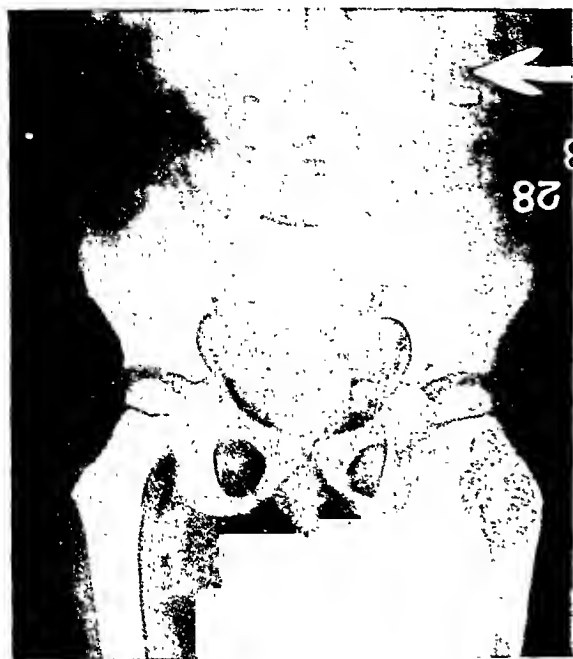


FIG. 1. Typical bone cyst. Ununited epiphysis, metaphyseal location, central area of bone destruction crossed by trabeculation.

directly beneath the periosteum, it may pulsate. Its rate of growth may be very rapid and cause perforation of the cortex. A mistaken diagnosis of osteogenic sarcoma is often made in such cases and amputation performed where more conservative therapy would have sufficed. This happened to one of the patients of this group who at age 35 developed a pulsating lesion over the left medial tibial condyle two months following a blow with a hammer. Biopsy was erroneously omitted and no inkling of the true diagnosis was available until the report was returned from the pathologist.

Giant cell tumors occur in elderly individuals but these are either of the spindle cell variety with a history of long duration or there is a remnant of the epiphysis. Roentgenograms of other than involved bones should be taken.<sup>5</sup>

Microscopy divides epulis into a fibrous and a giant cell variety homologous to osteitis fibrosa and giant cell tumor. It is said that the alveolar border is a veritable epiphyseal line, the deciduous teeth like

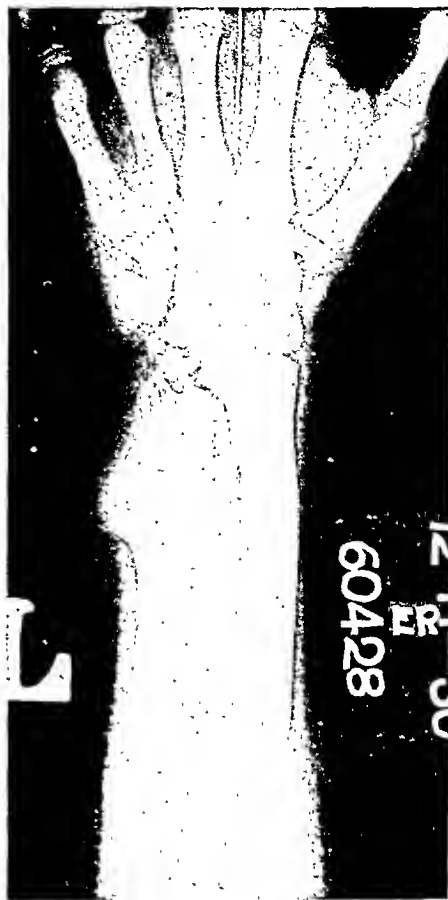


FIG. 2. Bone cyst following fracture. If there has been a fracture, a dense shadow of new bone formation is seen.

branous bone that serves as anchorage for the deciduous teeth. This accounts for the fact that epulis occurs in the young and never at the site of molars. In giant cell tumors of the tendon sheaths it is necessary to demonstrate some bony structure of cartilaginous origin. This Geschickter and Copeland have done. Giant cell tumors have been found to arise in the patella, a sesamoid bone. The giant cell xanthomata are tumors of sesamoid bones.

Malignant giant cell tumor is of two types: those that recur locally and those that metastasize. Although giant cell tumors do have a tendency to recur locally, this is usually due to incomplete removal, poor selection of treatment, or both. Metastatic tumors are usually mistaken diag-

noses—the lesion is an osteolytic sarcoma rather than a giant cell growth.

*Osteolytic Sarcoma.* There are two types



FIG. 3. The spindle cell variant of giant cell tumor. The spindle cells indicate a healing reaction. This patient had had the tumor forty-four years as a sequel to a baseball injury of the phalanx.

of osteolytic sarcoma, both rare. The *chondroblastic* sarcoma arises from a proliferation of cartilage at the epiphyseal line during puberty. Roentgenographically there is a mottled area of bone destruction with or without a slightly expanded bone shell. There is a definite periosteal reaction. Microscopically these lesions show a proliferation of chondroblasts which produce abortive areas of calcifying cartilage. At the margin of the tumor giant cells proliferate as a defensive reaction and attempt to remove calcified products of the tumor. The usual duration of the disease from onset until death is fifteen months. The finding of cartilage rules out giant cell tumor.

The *true* osteolytic sarcoma arises within the marrow in the shaft of long bones, shows a wide age distribution, produces pathologic fracture, and is frequently a pul-

sating lesion. Roentgenographically there is a central area of bone destruction without expansion of the cortex and without



FIG. 4. Osteitis fibrosa cystica of the chondrocranium. It is believed that the lesion to the right of the nose must have arisen from the ethmoid bone.

periosteal involvement. Microscopically, there are large spindle cells, rounded osteoblasts with numerous mitotic figures and a small amount of poorly formed osteoid tissue. The giant cells present in the lesion represent an attempt to remove the incompletely formed osteoid tissue. The average duration from the time of onset until death is twenty-two months. There are no cases of osteolytic sarcoma on record at the State University of Iowa Hospitals.

The rôle of trauma in the production of giant cell tumor is not always obvious, particularly when the lesion is in the chondrocranium. In the more rapidly growing types, such as the subperiosteal giant cell tumor, trauma plays a more obvious part. Certainly these lesions are related to the metabolism of the epiphysis and one finds

it hard to believe that the giant cell is not the essential part of the lesion. Given factors that will produce an environment favorable to the existence of the giant cell and unfavorable to the processes of repair, one may expect the formation of a giant cell tumor. Hyperparathyroidemia producing a calcium deficiency of bone will jeopardize the process of repair and permit the osteoclast to proliferate. Trauma may have a similar but less marked effect. Bleeding into bone where the only factor present to stop the bleeding is a pressure equivalent to the systolic blood pressure may, in a hemophiliac, give a similar picture.

The tendency for a metabolic imbalance to promote neoplasia is well known in medicine and has been emphasized by Trout and Kunath.<sup>6</sup> Fifteen patients, reported by the former author all had carcinoma of the breast, were treated with radical mastectomy, subsequently became pregnant and immediately developed carcinoma of the remaining breast, all dying a rapid and fulminating death.

Broders<sup>7</sup> raises the question as to whether malignancies are ever localized diseases. Carcinoma of the breast is related to the pregnancy hormones; tumors related to cartilaginous growth are stimulated by the parathyroid hormones. Everyone is aware of the work of Slye on the hereditary aspects of cancer. Broders, after a study of cancer in identical twins, has reached the conclusion that the stage for malignancy is prepared beforehand and, if the patient is alive when the time for cancer arises, he will suffer from it. He illustrates with one very interesting set of twins 92 years of age both of whom developed identical lesions in the left breast of identical grade of malignancy.

Geschickter voices this same idea in discussing tumors related to cartilaginous growth. "From a clinical standpoint the relationship between normal development and tumor formation makes the lesion and the age at which it occurs a most important consideration in the diagnosis and treat-

ment of the tumor. In fact, with few exceptions, the nature of the neoplasm with which the clinician is dealing can be



FIG. 5. Subperiosteal giant cell tumor of the tibia. This was a pulsating lesion, the cortex was perforated, but there was no periosteal reaction. An erroneous diagnosis of osteogenic sarcoma was made and amputation performed. Local removal would have sufficed.

readily restricted to a limited number of possibilities of the nature of the tissue development at the age and site where the tumor occurs is given adequate consideration."

That cancer is inherited does not explain the mechanism of its production. It is believed that the endocrines play an even more subtle part in the production of neoplasia than is usually conceded.

In the treatment of these lesions little has been added since the time of Nélaton other than the use of radiation therapy. Nélaton stated in reference to therapy:

"31. Extirpation, pure and simple, merits almost no confidence. If extirpation

consists of simple excision of the tumor, or even of the breaking up, uprooting, or finger extraction, it almost never (unless perhaps in the encysted, enucleated variety) succeeds in securing completely disappearance of the lesion; extirpation constitutes most often, as long as there remains the least shred of tissue adherent to the bone substance, merely a palliative and illusory operation, soon followed by recurrence.

"32. The application of hot irons is equally futile, in most cases. . . .

"33. Scraping, crumbling with a gouge, and above all, chemical caustics, particularly zinc chloride (Conquoin paste) carry out the procedure more efficiently.

"34. Extirpation combined with scraping or with potential cauterization affords hope for true success, at least as far as subperiosteal tumors are concerned."

Interestingly enough, no patient described in this series received the combined treatment of curettage, chemical cautery, bone graft, immobilization and Roentgen therapy.

## CONCLUSIONS

A survey of tumors related to cartilaginous growth is presented with emphasis on the similarity of these lesions and the inclusion of the generalized type of osteitis fibrosa cystica in the classification, thus relating these tumors to the endocrine mechanism. Stress is placed on the fact that these neoplasms occur at certain ages, the activity of the osteoclast and its ability to become malignant or benign depending on its stimulant.

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# THE COMPLICATIONS OF EMPYEMA IN CHILDREN\*

CHARLES W. LESTER, M.D.

Attending Thoracic Surgeon, Hospital for Ruptured and Crippled; Associate Surgeon, Bellevue Hospital

NEW YORK, NEW YORK

THE Empyema Commission of the United States Army promulgated certain principles in the treatment of empyema thoracis which have greatly lowered the mortality of that disease. We believe, with Bohrer, Heuer, Graham, Berck and others, that the mortality of uncomplicated empyema should be practically nil if these principles of adequate drainage at the proper time are followed, and that it makes no difference what manner of surgical attack is used as long as it follows these principles. The complications are, therefore, responsible for the death rate and for a prolonged convalescence. Thus, in the present state of our knowledge, the complications are of greater importance than the disease.

We have made a study of the complications arising in the cases of empyema occurring on the Children's Surgical Service at Bellevue Hospital, New York City, during the past ten years. Bohrer has already reported on some of these cases in a paper dealing with the general aspects of empyema in children; the present communication will therefore deal entirely with the complications. There are 248 cases in the series, in 179 of which there were 283 complications, thus leaving only sixty-nine cases—slightly more than one-quarter—without complications. Most of the patients received their entire treatment at Bellevue, the others arriving at Bellevue after having been in one or more hospitals during the previous stages of their disease. This may make our figures for complications a little above the average but it also gives us more cases for discussion.

Since empyema is itself a complication of some other disease it may be difficult to tell

whether the complication under discussion is that of the empyema or of the primary disease. For the purposes of this paper those conditions are considered as complications which arose after the empyema had become established or those existing before the onset of the empyema but which had an effect on its course.

TABLE I  
PRINCIPAL CAUSE OF DEATH

Septicemia.....	9
Exhaustion.....	4
Pneumonia.....	4
Brain abscess.....	2
Peritonitis.....	2
Tension pneumothorax .....	2
Meningitis.....	1
Pulmonary tuberculosis. ....	1
Ruptured trachea. ....	1
Shock.....	2

Table I gives the principal cause of death in the twenty-eight fatalities. It will be noted that empyema per se is not listed and the only death that in any way could be considered as due to empyema was that of shock. This occurred in a six weeks' old infant on whom it became necessary to do a simple intercostal closed drainage to relieve dyspnea caused by a great collection of pus in his chest. Three other patients died before the empyema had reached the operable stage, which reduces the mortality in surgical empyema to twenty-five cases.

Table II gives the occurrence of the principal complications and the number of times each occurred among the fatalities, regardless of whether it was considered the chief cause of death or only a secondary factor. This will explain the discrepancy between the two tables.

Septicemia is seen to be the most serious complication and the one responsible for the greatest number of deaths. In the fatal

\* From the Children's Surgical Service, Bellevue Hospital, New York City, Fenwick Beekman, M.D., Surgeon-in-Charge.

cases the blood culture showed hemolytic streptococcus in each instance. In six cases, which include the three nonoperative cases mentioned above, the chest fluid also contained the same organism. In the other three, culture of pus from the chest showed pneumococcus. Two patients with positive blood culture recovered. One had a *Streptococcus viridans* and the other, hemolytic streptococcus. Several patients had a

TABLE II  
COMPLICATIONS

Complication	Number	Deaths*
Septicemia.....	11	9
Peritonitis.....	4	4
Pericarditis.....	2	2
Meningitis.....	3	3
Brain abscess.....	2	2
Brain embolus.....	1	0
Exhaustion.....	4	4
Secondary infection.....	6	3
Contagious diseases of childhood....	26	1
Otitis media and mastoiditis.....	35	4
Pneumonia.....	14	5
Bilateral empyema.....	7	0
Bronchiectasis.....	7	0
Lung abscess.....	3	1
Inadequate drainage.....	59	3
Osteomyelitis of rib.....	27	0
Tuberculosis.....	6	1
Bronchopleural fistula.....	31	7
Chronic empyema.....	12	0
Late recurrence.....	4	0
Cellulitis of chest wall.....	4	1
Perforation of diaphragm.....	3	0
Miscellaneous.....	12	3

\* The figures in this column do not correspond with those in Table I, because every complication associated with a fatality is listed, not just that primarily responsible for each death.

positive pneumococcus blood culture during the antecedent pneumonia, but the blood culture was sterile before the onset of the empyema.

Pericarditis and peritonitis as complications are simply local manifestations of the general septicemia. Both patients with pericarditis had positive blood cultures. The two with peritonitis also had a positive blood culture, and in the other two blood culture was not taken.

Meningitis would naturally be considered as a result of a septicemia and in two of the three cases positive blood cultures were obtained. In the third no organism could be grown from the blood. All were fatal.

The treatment of these conditions does not differ from their treatment under other circumstances. Since the hemolytic streptococcus plays such an important rôle, sulfanilamide should be tried, but in the presence of an overwhelming infection too much should not be expected of it. Blood transfusions may be of value.

Brain abscess frequently has its genesis in some intrathoracic suppuration, but the frequency of empyema as a cause varies with different investigators. Thus Nickerson found it in only one case out of twenty, Schorstein in fifteen out of sixty-nine, and Cohen in four out of nineteen. In our series brain abscess occurred twice and each time was fatal, although in one case it was possible to localize and drain the abscess. This prolonged life but did not alter the ultimate outcome.

One child apparently had two attacks of cerebral embolus but recovered. This was a 7 year old boy who developed postoperative pneumonia after appendectomy for acute appendicitis. He apparently recovered but returned to the hospital two weeks after discharge suffering from pleurisy with effusion. This progressed to empyema which was drained three weeks later by rib resection. On the twenty-fifth day after the empyema operation he suddenly developed headache, convulsions, dyspnea, cyanosis, nystagmus and pathologic reflexes, and went into coma. In about a day he began to improve and in three days seemed completely recovered. Nineteen days later he repeated the same performance and likewise recovered. The neurologists made the diagnosis of cerebral embolus.

The patients with brain abscess followed the same chain of events, but finally died. *Streptococcus viridans* was found in the empyema pus of each of these three cases



and also in the pus from the brain abscess which was drained.

In a disease which is always a complication, and in most instances may be but one of several complications, exhaustion must play an important part. Maes and his associates found that 40 per cent of the deaths were due to exhaustion and toxemia. In our series exhaustion seemed imminent in most of the cases and in four appeared to be the deciding factor in a fatal outcome. Children withstand a prolonged infection poorly and the younger the child the lower the resistance. By the time a child has passed through the various illnesses which precede operable empyema he is pale, weak, listless and irritable. He has a certain amount of fever and is obviously toxic. A case in point is that of a six months old boy who had in turn varicella, retropharyngeal abscess, cervical lymphadenitis, lobar pneumonia, bilateral otitis media and finally empyema. The empyema was drained by means of a flapper tube in an intercostal incision, but the child developed a pyocyanous infection in his wound in addition to the original staphylococcus infection and died.

To combat this exhaustion we build up the fluid reserve which is nearly always depleted, transfuse the patient, and put him under the care of special nurses. The simplest possible operation is done, but even then some of these patients die.

In any children's service the contagious diseases of childhood are dreaded complications—dreaded alike for their effect on the patient and on the other inmates of the ward. These diseases appear as complications in twenty-six instances in this series. Measles was the most frequent, with sixteen cases, among which was one fatality. The other diseases were found in only one or two instances each. Measles developing before the empyema is not considered a complication although there were eight such cases in this series. It is obvious that the relationship between empyema and a complicating contagious disease of childhood is only casual.

On the other hand acute otitis media can be considered to have a direct relationship to the empyema or its antecedent infection. As would be expected this was a common complication occurring thirty-five times. Of these, six developed mastoiditis and four died. A great many other patients had running ears which started before the empyema and are not listed as complications. It is hardly necessary to state that ears should be inspected first in trying to determine the cause of an unexpected temperature rise.

Pneumonia as a complication of empyema may be an extension or recurrence of the original pneumonia; or it may be a new disease on the opposite side. It is a particularly serious complication with a 36 per cent mortality in our cases. Naturally, a severe disease such as pneumonia, arising in a child already approaching exhaustion from a long battle with infection brings with it a high death rate. The second pneumonia may occur before the empyema is ready to be drained or it may appear late when the empyema is nearly well. As would be expected, the later in the post-operative course that the second pneumonia appears the greater the chances for recovery.

When empyema follows the second pneumonia thus making a second empyema the prognosis is good. Apparently a patient who has sufficient resistance to combat the second pneumonia long enough to form empyema will recover under proper treatment. Thus, of fourteen patients with secondary pneumonia five died and seven developed empyema. There was no fatality among the seven cases of double empyema although in one instance the second empyema followed the first so closely that they were drained on successive days.

Bronchiectasis may be caused by repeated attacks of pneumonia and it is not unlikely that during some one of these attacks of pneumonia empyema will develop. Likewise, lung abscess may be a cause of bronchiectasis and may also cause empyema by perforation into the pleural cavity.



Seven of our patients had empyema as a result of one of these conditions which in turn was followed by bronchiectasis. There was no connection between the empyema and the bronchiectasis except that they were both complications of another disease.

We now come to a series of complications directly related to the operation rather than the infection. Insufficient drainage or pocketing of sufficient importance to require a secondary operation occurred fifty-nine times—the most common complication of the entire series. Three patients died, but other complications were responsible for the fatality and the pocketing was of minor significance.

Bohrer has already described our method of surgical attack and I will not repeat it other than to say that while we limit ourselves to no particular types we usually do an intercostal thoracotomy or rib resection using a flapper tube as a drain. As most of the cases requiring secondary operation had simple intercostal drainage in the first instance it might be thought that a more radical operation such as rib resection would be a better procedure. This we do not believe to be the case.

By the time a child has developed empyema in an operable stage he has been through a long, serious illness and is in a weak and toxic condition. The undrained infection causes toxemia much greater than the temperature would indicate and the patient is in no condition to tolerate anything but the quickest and least traumatizing operation.

Intercostal drainage can be done under local anesthesia, in bed, with a minimum of shock. It is therefore ideal for these patients and is often a life-saving procedure. Even if the drainage does prove to be insufficient it has allowed the patient to improve enough so that later he can stand the more extensive procedure of rib resection with safety.

Blocked drainage tube from fibrin plugs or rising diaphragm may allow the granulations to wall off a cavity at a distance from the tube. Too early removal of the tube can

cause the same thing. In this connection it must be remembered that the pleural cavity may be able to tolerate a large amount of pus without giving a febrile reaction and hence the responsible surgeon should inspect the dressings frequently to be sure that the drainage is adequate. If he waits for a temperature rise it may be too late. Drainage tubes should not be removed until the cavity has been obliterated, for the same reason.

Occasionally the empyema is loculated and the intercostal drainage will drain only one pocket. Then the fibrin plaques will have to be left until they liquefy. Should they organize before this happens, secondary operation becomes necessary. That this is not a frequent condition can be seen by the fact that fully half of the cases with uncomplicated recovery had only intercostal drainage.

Late recurrence is not particularly uncommon and appeared four times in this series. No fatalities occurred and the condition responded promptly to adequate drainage. The original empyema had drained longer than usual in each case so it is probable that a more complete drainage in the first instance would have prevented the late occurrence. Six years was the longest interval in our series but Meade reports a case recurring after ten years.

Osteomyelitis of the rib is listed as a complication in twenty-seven cases of which sixteen had intercostal drainage. Pressure of the tube against the adjacent ribs may well have been a cause in the intercostal drainage cases. In many other instances the operator described a pocket adjacent to the osteomyelitis in a sinus of long standing and the impression is inescapable that the undrained pocket was responsible for the failure to heal rather than the bare bone felt by the examining probe. Without the underlying pocket the osteomyelitis would probably have taken care of itself. This does not apply to frank osteomyelitis with sequestration which is not particularly rare although probably not so

frequent as our figures would seem to indicate.

With respect to chronic sinuses, consideration of the six cases in which tuberculosis appeared as a complication is of interest. The obvious thought in the association of tuberculosis with empyema is that a tuberculous pleural effusion or empyema had become secondarily infected, but this occurred in only one case which was also the only fatality attributable to tuberculosis. In the other five cases tuberculosis appeared in a sinus tract of long standing through which acute empyema had been drained. In four of the cases no involvement of the lung could be demonstrated. The other case is worthy of a brief summary.

The patient was a 7 year old girl admitted with pneumonia. On admission a Mantoux test was negative. In due course she developed empyema from which pneumococcus Type 1 was obtained. The pus became too thick to aspirate and, as she was critically ill, intercostal closed drainage with suction and irrigation was established. The twentieth day after operation she had a positive pneumococcus Type 1 blood culture although the empyema seemed well drained. Her condition then began to improve slowly but ten weeks after operation an undrained pleural pocket was opened by resecting three ribs. It communicated with a bronchopleural fistula. Next she developed varicella and was transferred to Willard Parker Hospital (for contagious diseases). Upon her return the sinus was still open so a third operation was done in which two more ribs were resected and granulation tissue removed. Section of the latter showed it to be tuberculous and now the Mantoux was positive. Some time later tuberculosis was found in the contralateral lung and it was thought that she had a spread from the granulation tissue by way of the bronchial fistula. When last seen she had active pulmonary tuberculosis, an open chest sinus and tuberculous iritis and keratitis.

This is a rather extreme example of the damage which can be caused by a bronchopleural fistula. Ordinarily it will close spontaneously and often its presence is discovered quite by chance.

One of our patients had an unsuspected bronchopleural fistula and died of shock when Dakin's solution which was being used for irrigation was aspirated into the lung through the open fistula. Carlson and Bowers report another similar case of sudden death from the use of Dakin's solution in the presence of an unsuspected bronchopleural fistula; and J. H. Heyl has told me of a third. For this reason we seldom use irrigation in our empyema cases. On the other hand a bronchopleural fistula in the presence of a small empyema may permit sufficient drainage to bring about a spontaneous cure of the empyema without operation.

Bronchopleural fistula occurred thirty-one times and was associated with a fatal outcome in seven instances. In four of these fatal cases the bronchopleural fistula was of secondary importance to other and more severe complications. Another fatality has just been mentioned and in the other two the bronchopleural fistula caused a tension pneumothorax, the most dangerous effect of this complication.

Tension pneumothorax occurs when the fistula breaks through in such a way that a valve is formed permitting the air to enter the pleural cavity on inspiration but blocking its exit. This causes an abrupt collapse of the lung and shifting of the mediastinum with consequent embarrassment of the heart action. The patient suddenly becomes dyspneic; his pulse becomes fast and weak; and he may be cyanotic. If the positive intrapleural pressure is allowed to build up, death soon takes place from cardiac embarrassment. Not infrequently, however, in the older children the increased pressure closes the valve. Both our fatalities occurred in infants, one of eleven months and the other of fourteen months.

Immediate relief of the positive pressure must be obtained. This can most quickly be accomplished by aspiration of the air through a needle which may be left in or inserted again if the pressure rebuilds. If relief is not thus readily obtained inter-

costal drainage through a flapper tube or closed system is indicated.

One of our cases was that of a 4 year old girl who had undergone intercostal drainage for an encapsulated empyema. On her eighth post-operative day she suddenly developed dyspnea, cyanosis and rapid, thready pulse. She was in a critical condition for a short time and then began to improve. Because her empyema had already been drained, tension pneumothorax was not immediately considered and when it was discovered was found to originate from a bronchopleural fistula at a distance from the walled-off empyema. This eventually had to be treated by rib resection and packing whereupon the fistula closed spontaneously.

When these measures fail to close the fistula it may be due to a thickened pleura preventing expansion of the lung. Decortication of the lung may then be necessary and if this is not sufficient the fistula will have to be closed by a muscle-flap transplant.

The thickened pleura prevents expansion of the lung and produces chronic empyema, a complication occurring twelve times in this series. Decortication of the lung to permit expansion is usually all that is necessary although this may have to be combined with a thoracoplasty to close the dead space. The longer a chronic empyema exists the more will have to be done to correct it and it is therefore advisable to operate as soon as it becomes apparent that the lung will not expand to the chest wall.

Most of the chronic empyema can be avoided. Delay in operating is one preventable cause but this is less of a factor than inadequate drainage. Apparently a lung can stand collapse from a large collection of undrained pus without impairing its ultimate power of expansion much longer than it can a collapse due to inadequate drainage. It therefore behooves the surgeon to watch the drainage and the closure of the cavity and not to be led astray by a normal temperature.

Cellulitis of the chest wall is mentioned by various authors as an important complication but occurred in our cases but four

times. In one case it was associated with erysipelas, streptococcus septicemia and pneumonia, which brought about a fatal result. In the others it was due to an anaerobic infection along the tract of an aspirating needle in a putrid empyema. When a putrid empyema is suspected aspiration should not be done until all is in readiness to do a thoracotomy should the suspicions be realized.

Perforation of the diaphragm occurred three times. Twice it was due to a subphrenic abscess which perforated upwards to form the empyema and in the other case to tuberculosis.

Two cases were complicated by the presence of foreign bodies in the chest. In one instance a rubber dam drain slipped into the chest in one of our own cases (an accident of which we were aware) and required a secondary operation to recover it. The other case was that of a child who had been operated upon for empyema in his home three years before. Because it is so easy to lose drainage material in the chest, surgeons are on their guard and the accident is relatively infrequent.

Another accidental case of empyema is worth recording. It followed bronchoscopy for the purpose of removing a peanut which had become lodged in a bronchus of a 7 year old boy. While the instrument was in place he struggled and the trachea was perforated. Subcutaneous emphysema followed at once, necessitating tracheotomy. Pyopneumothorax developed and was treated by intercostal drainage but lung abscess further complicated the situation and resulted in death.

The remaining miscellaneous complications include nephritis, osteomyelitis of the tibia, suppurative arthritis, tonsillitis, carbuncle and multiple lung abscesses.

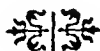
#### CONCLUSIONS

The fatalities of empyema are due to the complications which are, for the most part, the result of the original infection or of some intercurrent infection.

The nonfatal complications are of a similar nature and also arise from the surgery. Some of the surgical complications can be prevented.

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COLON bacilli frequently gain access to one or the other kidney by the close lymphatic connections of the colon with the kidneys, of the caecum and ascending colon with the right kidney, and of the descending colon and sigmoid with the left kidney. Urinary infection is common in ulcerative colitis, polyposis, diverticulitis, etc.

From—"Convalescent Care" (New York Academy of Medicine).

# AN EVALUATION OF SORBITOL AS A DEHYDRATING AGENT\*

JEFFERSON BROWDER, M.D.

AND

FLOYD H. BRAGDON, M.D.

BROOKLYN, NEW YORK

PITTSBURGH, PENNSYLVANIA

SINCE Weed and McKibben<sup>1</sup> demonstrated that the cerebrospinal fluid pressure could be reduced by the intravenous administration of hypertonic solutions of dextrose, sodium chloride, sodium sulfate and sodium bicarbonate, there has been an extensive application of this principle. The respiratory and cardiac disturbances observed in experimental animals following the intravenous injection of the sodium salts, as well as clinical experiences, militated against the use of these chemicals in the human. Further observations indicated that hypertonic solutions of dextrose given intravenously were attended by few untoward reactions and accordingly this chemical was employed extensively for the reduction of intracranial tension. There were, however, some undesirable features associated with the use of this carbohydrate, one in particular being that the reduction in cerebrospinal fluid pressure lasted for a relatively short period and not infrequently was followed by a secondary rise in pressure to a level well above that observed prior to the injection.

In the quest for a substance that would produce a prolonged reduction in pressure without undesirable by-effects, sucrose was investigated both experimentally<sup>2</sup> and clinically.<sup>3,4</sup> A 50 per cent solution of this chemical was found to be more effective, in that the reduction in cerebrospinal fluid pressure was commonly of longer duration than that observed following the injection of a comparable quantity and concentration of dextrose, yet the results were not uniformly satisfactory.

Recently another hypertonic solution, sorbitol, has been offered for clinical use as

an osmotic dehydrating agent and diuretic. This substance is reported to be a modified monosaccharide,  $C_6H_{14}O_6$ , derived from the reduction of dextrose or levulose. It appears not to be hydrolyzed to any extent when injected intravenously in the human and is rapidly excreted in the urine. In 50 per cent solution sorbitol possesses the high osmotic pressure of dextrose of the same strength and almost twice that of a 50 per cent solution of sucrose. Burget, Todd and West<sup>5</sup> injected large doses of 50 per cent solution of sorbitol intravenously into dogs without evidence of toxicity. These authors reported that the diuresis produced by this chemical was greater than that observed following the administration of an equal quantity of 50 per cent solution of sucrose.

The object of the present investigation was to determine the effect of sorbitol on the cerebrospinal fluid pressure, pulse, respiration, blood pressure and psychologic state in human subjects with and without disease of the central nervous system. Thirty-three patients with various diseases of the intracranial structures were studied, with five patients as controls who had neither clinical evidence of a pathologic process implicating the nervous system nor increase in the intracranial tension as measured by the cerebrospinal fluid pressure. The age of the patients ranged from 23 to 86 years and the male to female ratio was 4:1. Ten detailed studies concerning the cerebrospinal fluid pressure were carried out on nine patients. Clinical observations were made following each of the forty injections given to the remaining twenty-nine patients.

\* From the Neurosurgical Service, Kings County Hospital, Department of Hospitals, New York City.

## METHOD

For the detailed studies, the patient was placed in a lateral position with the cere-

state of consciousness were recorded, then 50 c.c. of 50 per cent solution of sorbitol were administered intravenously. During the subsequent six to eight hours

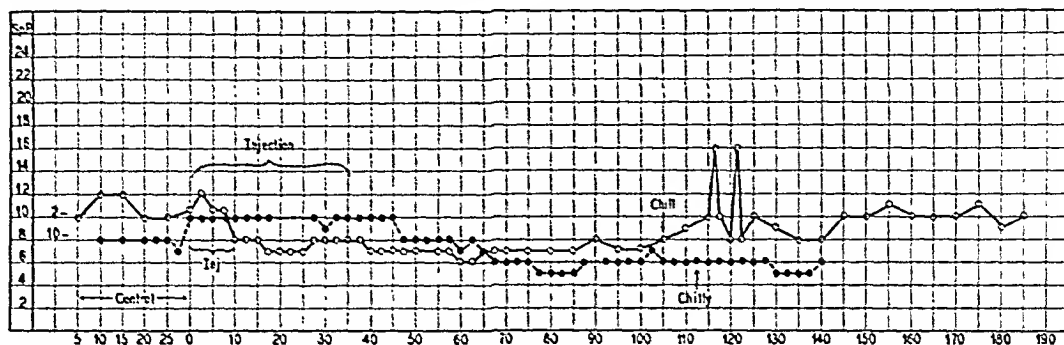


FIG. 1. Chart showing the cerebrospinal fluid pressure ( $S.P.$ ) in Cases 11 and X (normal controls). The period of injection of sorbitol was ten minutes in Case 11 (open circles) and thirty-five minutes in Case X (solid circles). Time recorded in minutes.

brospinal axis on a horizontal plane. The cuff of a sphygmomanometer was applied to the arm of the uppermost side and a stethoscope led away from the antecubital fossa. A 17-gauge spinal needle attached to a mercury manometer was introduced into the lumbar thecal sac without external loss of cerebrospinal fluid and the zero reading of the manometer placed at the level of the needle. As a control in each study, the mensuration of the cerebrospinal fluid pressure, blood pressure, pulse rate, and respiratory rate were recorded every five minutes throughout periods ranging from twenty to sixty minutes or until a constant level of all these factors was maintained. An injection of 50 c.c. of 50 per cent solution of sorbitol was then given into the antecubital vein of the arm of the lowermost side. The period of the injection of sorbitol was ten minutes in seven instances and forty minutes in the remaining three. The cerebrospinal fluid pressure readings were recorded every minute during the period of injection and every two and one-half minutes during the remainder of the observations, while the blood pressure readings, pulse rate and respiratory rate were noted every ten minutes.

For the clinical studies the patients were in the supine position. Observations concerning the blood pressure, pulse rate, respiratory rate, temperature, and the

these vital signs were determined and recorded at thirty minute intervals. The actual period of injection was ten minutes in seven instances and the remaining thirty-three injections were given slowly over periods ranging from thirty to forty minutes.

#### ABSTRACTS OF CASE HISTORIES USED IN THE DETAILED STUDIES

CASE 1. J. M., a 48 year old male, had had a craniotomy four and one-half months previously with subtotal removal of a right parietal glioma. The scalp over the cranial opening was moderately tense. During the period of control observations, the cerebrospinal fluid pressure was 17 mm. Hg., pulse 110 per minute, blood pressure 114/70 mm. Hg., and the respirations 36 per minute. Following the intravenous injection of 50 c.c. of sorbitol in eleven minutes, there was a gradual fall in cerebrospinal fluid pressure to 14 mm. Hg. The pressure was maintained at this level for one hour and fifty minutes at which time the observations were discontinued because of a severe chill which had been present for thirty minutes. There was no essential change in the vital signs prior to the chill. The area of decompression was less tense after the injection and the patient seemed somewhat more alert.

CASE 11. E. D. V., a normal 38 year old male, was a control subject. The cerebrospinal fluid pressure was 10 mm. Hg., pulse rate 73 per minute, blood pressure 116/76 mm. Hg., and respirations 20 per minute. An injection of

50 c.c. of sorbitol was given over a period of ten minutes, resulting in an immediate fall in cerebrospinal fluid pressure to 7 mm. Hg.

CASE IV. J. L., a 28 year old male complaining of severe intermittent headache of six months' duration, was conscious and alert.

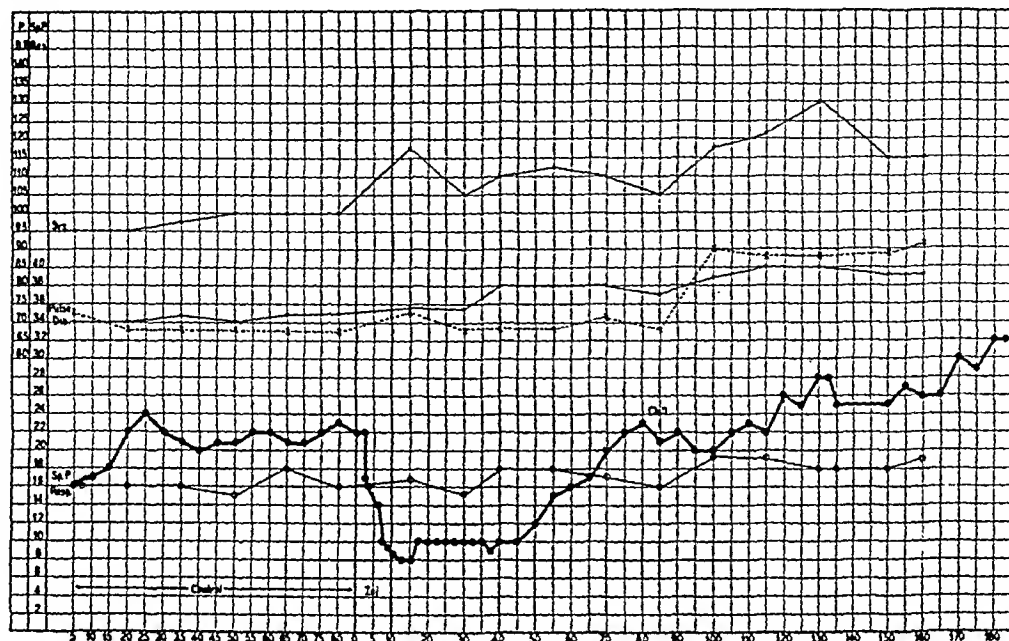


FIG. 2. Case v (brain tumor) showing the prompt reduction in cerebrospinal fluid pressure ( $S_pP$ ) following the injection of sorbitol, with subsequent secondary rise in pressure above the original level. Time recorded in minutes.

(Fig. 1.) There was no change in the pulse rate or blood pressure until a chill lasting thirty minutes occurred one and one-half hours after the injection, at which time the pulse rate increased to 96 per minute. There was no alteration in the state of consciousness during the period of observation.

CASE III. E. K., a 43 year old male, had sustained a severe brain injury and was alternately stuporous and restive at the time of observation, forty-four hours after injury. A right hemiparesis was demonstrable and seemingly a speech disturbance was present. The cerebrospinal fluid was contaminated with blood and the pressure was 10 mm. Hg. The pulse rate was 68 per minute, blood pressure 90/54 mm. Hg., and respirations 20 per minute. Following the intravenous injection of 50 c.c. of sorbitol in ten minutes, there was a prompt reduction in cerebrospinal fluid pressure to 4 mm. Hg. with a rise to 6 mm. Hg. at the end of forty-five minutes. It became necessary to discontinue the observations at this time because of marked psychomotor acceleration. At the conclusion of the observations the pulse rate was 74 per minute and the blood pressure and 106/70 mm. Hg.

An intramedullary mesencephalic lesion, presumably tumor, had been demonstrated by ventriculography on a previous admission. The observations are recorded in Figure 2. About one and one-half hours after the injection of 50 c.c. of sorbitol there was a chill lasting nine minutes. The state of consciousness remained unaltered.

CASE V. L. G., a 62 year old male, was moderately drowsy and presented clinical evidence of an intracranial neoplasm. Subsequent craniotomy verified a left frontotemporal metastatic tumor. The cerebrospinal fluid pressure was 40 mm. Hg., pulse rate 120 per minute, blood pressure 152/98 mm. Hg., and respirations 28 per minute. The intravenous injection of 50 c.c. of sorbitol in ten minutes reduced the cerebrospinal fluid pressure to 24 mm. Hg. where it remained for twenty minutes and then gradually returned to the control level, one hour after the completion of the infusion. One and one-half hours after the injection, the cerebrospinal fluid pressure was 56 mm. Hg. A chill lasting twenty minutes occurred at this time. The observations were concluded three hours after the injection, and at the time, the cerebrospinal fluid pressure was 40 mm. Hg.,



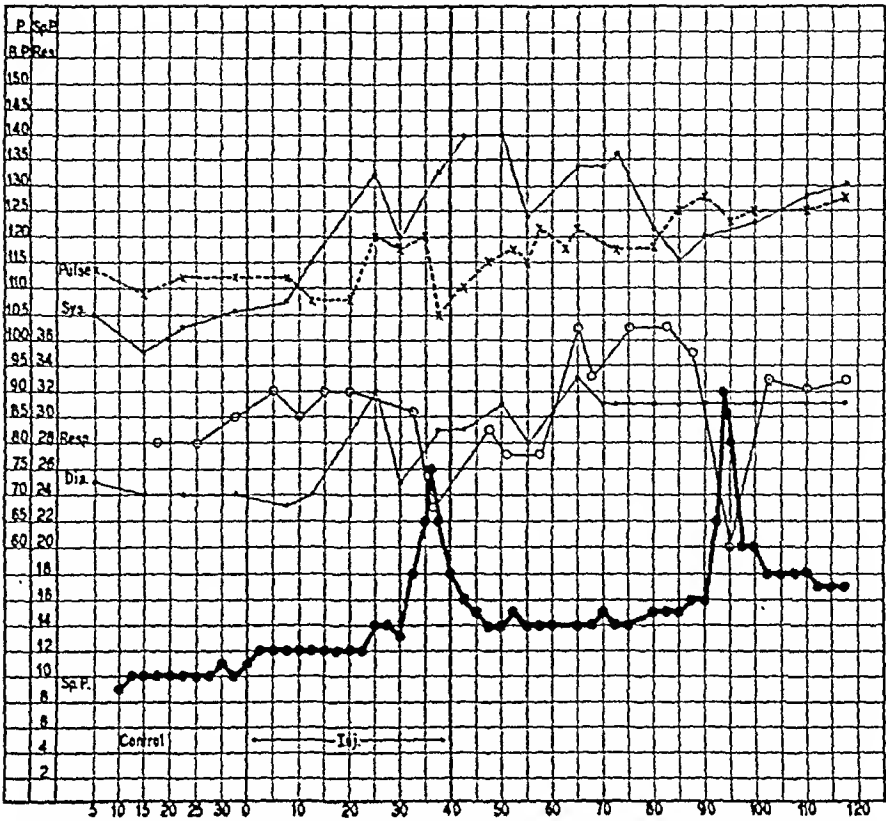


FIG. 3. Case ix (craniocerebral trauma), showing a progressive rise in cerebrospinal fluid pressure ( $S_P P$ ) following the administration of sorbitol and the associated alterations in the vital signs. Time recorded in minutes.

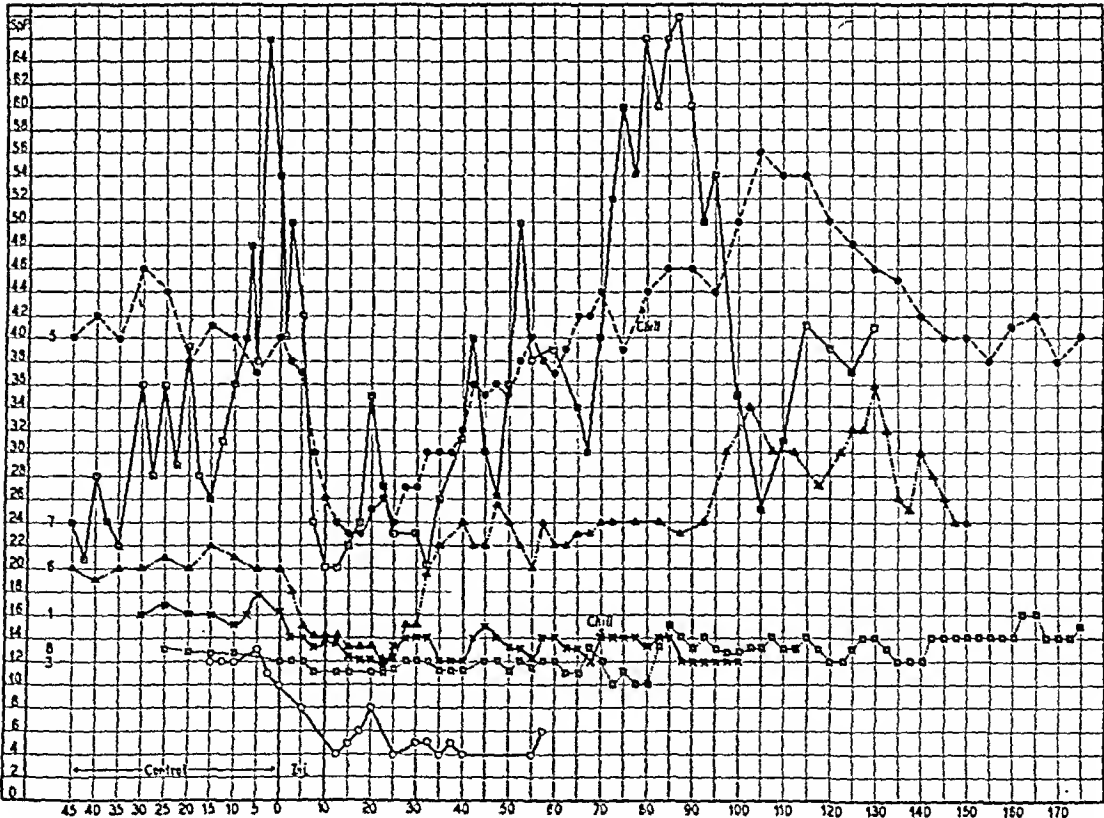


FIG. 4. Composite chart of the cerebrospinal fluid pressures in Cases i, iii, v, vi and vii, illustrating the variable effects following the injection of sorbitol. Note the marked spontaneous fluctuations in pressure in Case vii particularly. Time recorded in minutes.



pulse rate 130 per minute, blood pressure 154/106 mm. Hg. and respirations 30 per minute. There was no marked change in the state of consciousness.

CASE VI. The same patient used for the study recorded in Case v. The control readings established the cerebrospinal fluid pressure at 20 mm. Hg., pulse rate 90 per minute, blood pressure 158/98 mm. Hg., and respirations 22 per minute. The intravenous injection of 50 c.c. of sorbitol in eight minutes, reduced the cerebrospinal fluid pressure to 12 mm. Hg., but within forty-five minutes the pressure returned to the original level. A secondary rise in pressure to 34 mm. Hg. occurred one and one-half hours after completion of the infusion. At the conclusion of the observations two and a half hours after the injection the pressure was 26 mm. Hg. The blood pressure, pulse readings, and respirations remained essentially unchanged and the patient seemed somewhat more responsive.

CASE VII. H. S., a 48 year old male complaining of severe headache, was alternately drowsy and restive. Craniotomy performed subsequent to the study verified a large right frontal glioma. Although the patient was quiet and the blood pressure, pulse rate, and respirations remained constant during the control period of forty-five minutes, the cerebrospinal fluid pressure fluctuated between 40 and 60 mm. Hg. Following the intravenous injection of 50 c.c. of sorbitol during ten minutes, there was a reduction in the cerebrospinal fluid pressure to 20 mm. Hg. at which level it remained for about twenty minutes. There were no significant changes in the pulse rate, blood pressure or respirations. A secondary rise in pressure to 70 mm. Hg. occurred one hour after completion of the injection. At the conclusion of the observations, two hours after the injection, the cerebrospinal fluid pressure was 40 mm. Hg., pulse rate 50 per minute, blood pressure 106/60 mm. Hg., and respirations 14 per minute. There was no change in the state of consciousness.

CASE VIII. J. N., a 38 year old male, had a large left parietotemporal cranial defect, the result of a craniotomy performed six months previously with subtotal removal of a glioma. The patient complained of headache and was mildly drowsy at the time of this study. The control observations established the cerebrospinal fluid pressure at 12 mm. Hg., pulse rate

66 per minute and blood pressure 118/22 mm. Hg. During the infusion of 50 c.c. of sorbitol over a period of forty minutes, there was no essential change in the cerebrospinal fluid pressure. Two hours after the injection, the cerebrospinal fluid pressure was 14 mm. Hg., and remained at this level until the conclusion of the observations, three hours after the administration of the sorbitol. The headache was somewhat alleviated by the medication.

CASE IX. J. W., a 60 year old male, had sustained a severe craniocerebral injury eight hours prior to the beginning of the study. The patient was stuporous but would resist painful stimuli. No gross paralysis of the extremities could be demonstrated. The cerebrospinal fluid was contaminated with blood. During the intravenous infusion of 50 c.c. of sorbitol over a period of forty minutes, there was rise in the cerebrospinal fluid pressure, associated with irregular respirations. The observations are recorded in Figure 3. A mild chill lasting eight minutes occurred one and a quarter hours after the injection. The stupor appeared to be more profound at the conclusion of the observations.

CASE X. J. S., a healthy 32 year old male, without demonstrable evidence of disease of the central nervous system, was a control subject. An injection of 50 c.c. of sorbitol was given over a period of forty minutes. The cerebrospinal fluid pressure is recorded in Figure 1. The pulse rate, blood pressure and respiratory rate maintained a normal level during the observations. A chilly sensation with "goose-flesh" over the body, lasting twelve minutes, occurred two hours after the infusion. There was no change in the state of consciousness.

#### CLINICAL STUDIES

In this group twenty-nine patients were used as subjects in forty observations. Three patients without evidence of central nervous system disease and four with brain tumor (preoperative) were each given a single injection of sorbitol; three patients (postoperative brain tumor) with large cranial defects were given a total of seven injections; twelve patients with craniocerebral trauma received fourteen injections; two patients with postoperative brain edema three injections; five patients with miscellaneous disorders, including post-traumatic syndrome, were given a

total of nine injections. The three patients used as controls showed no obvious changes in the psychologic or constitutional state following the injection, aside from chills with an accompanying acceleration of pulse. Improvement, as evidenced by a more lucid state of consciousness, relief of headache and frequently a disappearance of some of the abnormal neurologic findings, was recorded in twenty of the thirty-seven observations. The degree of improvement was not uniform in all types of cases as indicated in Table 1. A severe chill, lasting

TABLE 1

Type of Case	Percentage Improved
Brain tumor (preoperative).....	50
Brain tumor with decompression (postoperative).....	14
Craniocerebral trauma (acute).....	57
Brain edema (postoperative).....	66
All others (post-traumatic syndrome).....	77

from three to thirty minutes, followed by a febrile rise to 103 or 104°F., occurred after thirteen injections while mild reactions characterized by chilly sensations, "goose-flesh," and a mild febrile rise followed six injections. There were no significant changes in pulse rate, blood pressure, respiratory rate or temperature in instances not associated with a chill. Mild to moderate cyanosis of the mucosa and nail beds was noted on several occasions after the injection, particularly in the cases of cranio-cerebral injury.

#### DISCUSSION

The intravenous injection of sorbitol in each of the two patients used as controls (Cases II and X) in the detailed studies resulted in a mild reduction of cerebrospinal fluid pressure in both instances. In one, the reduction was sustained for 140 minutes (observations discontinued at this time) and in the other for 120 minutes followed by a return of the pressure to the pre-injection level where it remained until the conclusion of observations (190 minutes after injection). Similar results have been observed following the injection of both dextrose and sucrose. For example, in

Case II an injection of 100 c.c. of 50 per cent solution of dextrose effected a reduction in cerebrospinal fluid pressure that was sustained for 220 minutes (observations concluded at this time). An injection of 100 c.c. of a 50 per cent solution of sucrose given forty-eight hours later did not appreciably alter the cerebrospinal fluid pressure during a period of observation of 190 minutes.

The reduction in cerebrospinal fluid pressure observed by Weed in the animal experiments following the administration of dehydrating agents is, in general, comparable to that observed by us in the normal human. Weed reported an individual tolerance of each animal so that, consequently, the effects of a drug could not be predicted in advance. We have found the same to be true in the human.

This inconstancy of behavior in the cerebrospinal fluid pressure that may follow the injection of a dehydrating agent is even more marked in instances associated with increased intracranial tension. A comparison of Figures 1 and 4 emphasizes this fact. The latter depicts the cerebrospinal fluid pressure in six patients presenting evidence of varied intracranial pathologic processes. Rapid spontaneous fluctuations in pressure ranging from 20 to 40 mm. Hg. were noted in several instances during the period of control observations. This phenomenon usually disappeared during the period of reduced pressure produced by the injection of sorbitol but promptly recurred when the cerebrospinal fluid pressure returned to or exceeded the original level. Frequently a complete oscillation in pressure has been observed in five seconds. There was no physical effort on the part of any of the patients nor significant change in the vital signs associated with this phenomenon. Many of the patients in whom this was observed complained of sudden severe headache during the rise in cerebrospinal fluid pressure and relief was experienced as the pressure receded.

In three instances (Cases I, VI and VIII), there was clinical improvement following

the injection of the sorbitol and in each experiment there was a reduction in cerebrospinal fluid pressure with a minimal secondary rise, the final pressure remaining near the original level. In four of the studies, (Cases iv, v, vii and ix), improvement was not observed. In three of these there was a reduction in cerebrospinal fluid pressure followed by a marked secondary rise, the pressure at the conclusion of the observations remaining higher than the pre-injection level. In the fourth, a patient with a severe craniocerebral trauma, there was an immediate progressive rise in cerebrospinal fluid pressure following the injection and at the conclusion of the study the pressure was more than twice the original level. (Fig. 3.) A similar effect following the intravenous injection of 50 per cent solution of dextrose has been previously reported by one of us<sup>6</sup> and again it should be stressed that the administration of dehydrating agents during the first twenty-four to forty-eight hours following severe brain trauma is not without danger.

In five of the patients in this series, studies had previously been conducted utilizing 100 c.c. of 50 per cent solution of dextrose and an equal quantity and concentration of sucrose. The 100 c.c. dose was used as a standard in these observations while the recommended dosage of 50 c.c. of sorbitol was used in the present study. The changes in the cerebrospinal fluid pressure following the intravenous injection of 50 c.c. of sorbitol were similar to those observed following the administration of 100 c.c. of dextrose, there being an initial reduction in pressure followed by a marked secondary rise in three of the five cases. The reduction in pressure effected by the injection of 100 c.c. of sucrose in the same patients was not associated with a secondary rise. There were no significant disparities in the changes effected in the cerebrospinal fluid pressure following the injection of sorbitol, dextrose, or sucrose in the remaining two cases.

A severe chill associated with a febrile rise to 103 or 104°F., occurred in four instances and chilly sensations in two additional cases in the ten detailed studies. In the entire series of fifty injections, a chill occurred in seventeen and chilly sensations were reported in eight additional instances, making a total of twenty-five, or an incidence of 50 per cent. Chills

TABLE II  
CLASSIFICATION OF CASE STUDIES WITH DISTRIBUTION  
OF REACTIONS

	Injections	Chills	Mild Reaction
Controls.....	5	1	1
Brain tumor (preoperative)....	8	3	0
Brain tumor with decompression (postoperative).....	9	5	1
Brain trauma (acute).....	16	5	3
Post-traumatic syndrome, etc...	8	1	2
Postoperative brain edema.....	3	2	1
Postencephalography.....	1	0	0
	50	17	8

were observed less frequently in those patients in whom a relatively normal intracranial tension was recorded. The rate of injection seemed to be a factor in the production of this reaction, there being an incidence of 64 per cent following the rapid injection technique (ten minutes) in comparison with 40 per cent after the drip method (thirty to forty minutes). One patient (Case 1) was given four injections of sorbitol, one by the rapid and three by the drip method, and following each there was a severe chill. In this individual, previous injections of 100 c.c. doses of 50 per cent solution of both dextrose and sucrose had been unattended by a chill. It is worthy of note that the severe chills observed during the detailed studies did not materially influence the cerebrospinal fluid pressure except in Case 11 as recorded in Figure 1. In this instance during the height of the chill, a rapid rise and fall in pressure occurred twice in five minutes.

## SUMMARY AND CONCLUSIONS

A total of fifty intravenous injections of sorbitol was given to thirty-eight patients representing a variety of intracranial lesions. Clinical improvement as evidenced by a more lucid state of consciousness and relief of headache was noted in 54 per cent. Detailed observations concerning the cerebrospinal fluid pressure, pulse, blood pressure, respirations and psychologic state were recorded in ten experiments. Included in the detailed studies were two patients without evidence of central nervous system disease. In each experiment on the two subjects a slight reduction in cerebrospinal fluid pressure was effected and sustained for over two hours. In four of the five patients in whom an elevation in cerebrospinal fluid tension was demonstrated, the injection of sorbitol produced an immediate reduction in the pressure, followed by a secondary rise to a level higher than that observed prior to the injection. In a patient who had sustained a recent craniocerebral trauma there was an immediate progressive rise in cerebrospinal fluid pressure to twice the original level following the injection.

In general, the action of sorbitol as measured by the reduction in cerebrospinal fluid pressure is comparable to dextrose but less satisfactory than sucrose. The frequent occurrence of chills following the intravenous injection of this chemical militates against its use as a dehydrating agent.

The sorbitol utilized in this study was donated by Abbott Laboratories.

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# MESENTERIC VENOUS OCCLUSION: A CLINICAL ENTITY

MERLE J. BROWN, M.D., M.SC.

DAVENPORT, IOWA

THERE have been about 772 cases of mesenteric vascular occlusion reported and discussed in the literature but most of the writings concern arterial occlusion. The author believes with Donaldson and Stout, and with Warren and Eberhard that venous occlusion is a separate clinical entity and should be treated as such in the medical literature. The aim of this paper is to present additional data on the clinical picture of mesenteric venous occlusion to make this lesion more clear cut.

## ANATOMY

Anatomically, the venous and arterial systems of the mesentery are quite different. The arterial system is the more simple of the two groups of vessels, with the superior mesenteric artery arising from the aorta at an acute angle immediately below the celiac axis and its main stem paralleling to some extent the course of the abdominal aorta. Thus it may be seen that the superior mesenteric artery has a direct connection with the heart and thereby is vulnerable to emboli from above. In contrast to the arterial distribution all blood collected in the veins of the abdominal part of the digestive tract (except the lower part of the rectum), spleen, pancreas, and gall-bladder passes into the portal vein by which it is filtered through the liver, then through the hepatic veins to the vena cava. The liver in this system of veins may be compared to a dam with spillways between two large reservoirs of venous blood. Any thrombus arising in the liver may pass on as an embolus into the cephalad channels, producing damage where it lodges. An embolus, as such, could not pass into the caudad channels against the current of venous blood, but a thrombus arising in the liver or below could block off the venous channels, resulting in a descending thrombosis extending

into part or all of the branches of the superior mesenteric vein. In contradistinction, a thrombus arising in the smaller radicles of this vein may give rise to an ascending thrombosis or become embolic to produce infarction of the liver. The anatomic factors of the venous system predispose to thrombosis more than those same factors do in the arterial system.

## PATHOLOGY

Virchow reported the first case of vascular occlusion of the superior mesenteric artery and later studies were made by Jackson, Porter and Quinby (1904) and Trotter (1913). The pathologic result of the occlusion in the intestine has been fairly well established, while the initiating pathologic states are not agreed upon entirely. Warren and Eberhard, in quoting Sprengel, stated that either arterial or venous occlusion is due to sudden embolism, while venous occlusion results from a slower progressive thrombosis, but that the difference in speed of events may not be obvious clinically until the compensatory powers of the body are overcome by a failing circulation. Typical acute symptoms then appear without warning. In addition to physiologic changes in the intestinal tract and its blood vessels, Donaldson and Stout considered such lesions as intussusception, volvulus, general debility of acute infections, trauma, acute and chronic enteritis and infective or other emboli as initiating pathologic states in venous thrombosis.

Whittaker and Pemberton found 60 per cent of sixty cases unrelated to previous operations while 40 per cent definitely followed surgery. Thrombosis occurred more frequently in surgical patients with lesions predisposing to thrombus formation such as splenic anemia and arteriosclerosis. These authors considered that mesenteric venous occlusion occurs secondary to a

descending thrombosis from hepatic and portal lesions. Associated portal thrombosis was found in 30 per cent of the cases and pulmonary thrombosis in 11.6 per cent. Previous attacks are indicated by finding old organized and non-occlusive clots in a few cases. Voigt stated that a poor prognosis of appendicitis in older persons may be due to mesenteritis, lowered resistance and degenerative diseases predisposing to thrombosis. Feldstein and Goldstein reported a case involving the superior mesenteric vessels due to prolonged suppuration of the mastoid. Skinkawa and Mari mentioned a case caused by calcification of a mesenteric lymph node. Boyce and McFetridge found that the origin and evidence of occlusions cannot always be determined.

The immediate gross pathology resulting from venous occlusion is variable. The involved bowel segment becomes dusky and dark red in color with loss of sheen. The intestinal wall is edematous and thickened, while beneath the serosa a gelatinous appearance exists. The mesentery is thickened and edematous with loss of mobility and there are palpable nodular areas (due to thrombi within the vessels) in the involved portion. The mesentery may be pale or present an extension of the dusky red color from the intestine, but any discoloration may be hidden by mesenteric fat. The involved mucous membrane is red, hemorrhagic, and swollen, not showing ulceration. Douglas considered that color alone is insufficient to determine viability but that escaping blood from a surface pinprick and careful observation of circulation may help determine the extent of resection necessary. Lower and Glazer, by microscopic section, showed the involved bowel and mesentery in their case to have extensive edema, venous engorgement, and extravasation but no ulceration of the mucous membrane.

#### ETIOLOGY

In reviewing the literature one is impressed by the multiplicity of initiating pathologic lesions ascribed to the causation

of venous and arterial occlusion. Practically all of them, however, can be classified under the following main divisions:

1. Debilitating and degenerative diseases.
2. Inflammatory lesions of the abdomen.
3. Neoplastic diseases of the abdomen.
4. Mechanical factors (surgery, trauma, obstruction and hernia).
5. Undetermined origin of the thrombosis.

Oschner stated that an insufficiently appreciated cause of mesenteric venous occlusion is associated with prolonged ingestion of alcohol and that the prognosis in this type is good. He reported five such cases, all of which were operated upon and only one resected, with the recovery in those not resected. Larson found that venous thrombosis most often resulted from abdominal septic processes; 31 per cent followed appendicitis and twenty-five were associated with liver disease. Green wrote that fatigue and prolonged emotional strain may cause venous occlusion, following a study of his cases and the experiments of Cannon, showing that increased adrenin due to these factors decreased clotting time of the blood to one-half. Brady stated that if a patient with cirrhosis of the liver or endocarditis suddenly develops an acute abdominal condition, one may suspect mesenteric thrombosis.

#### ADDITIONAL STATISTICS

This study was made on 101 cases of venous occlusion taken from the literature, two from the Guthrie Clinic, and one from the author's experience. The source of the cases is shown in Table 1.

It was found that of 100 patients of known age, the youngest was four months and the oldest 76 years. It is obvious that no age is exempt from this catastrophe. (Table II.) The average for all patients was 43.1 years, while the age range for the greatest incidence was 21 to 70 years. The decade of life with the greatest incidence was 50 to 60 years. When these figures are interpreted, venous occlusion occurs most

often at the age in which degenerative diseases begin to make their appearance.

TABLE I

Author	No. of Cases	Deaths	Recoveries
Brady.....	7	5	2
Larson.....	16	16	0
Douglas.....	1	0	1
Lower and McCleery.....	1	0	1
Wood.....	4	4	0
Pollock.....	1	0	1
Mallory.....	1	0	1
Mathews.....	1	0	1
Milch and Masotti.....	1	1	0
Donaldson and Stout.....	3	3	0
Warren and Eberhard.....	65	39	26
Guthrie Clinic.....	2	2	0
Author's case.....	1	1	0
Totals.....	104	71	33

TABLE II

Ages	No. of Cases
0-10	2
11-20	7
21-30	18
31-40	18
41-50	17
51-60	24
61-70	13
71-80	1

An attempt was made to correlate the length of time of illness before the patient came to surgery, with recovery or death, in order to show some prognostic index. There were nineteen recoveries out of a total of thirty-three patients who had been ill for an average of 13.5 days before operation. Fourteen stated that the onset was sudden and these were presumably operated on without delay. It will be seen that 57.5 per cent of the patients recovering had been ill for nearly two weeks. This does not support the calculations of Warren and Eberhard that the mortality rate increases from 25 per cent in the first twelve hours to 83.3 per cent after four days. Among the seventy-one deaths in this series of 104 cases, forty-six patients had an average preoperative illness of 15.4 days; nine patients claimed sudden onset of the illness; three deaths followed

surgery for other conditions; six patients were ill from a few to several days; in four cases there were no data; and one patient claimed illness for several years.

In this survey it was found that associated pathology occurred in a number of these 104 cases. Although the records may be incomplete from this standpoint, appendicitis occurred nineteen times (17.7 per cent) and was considered the initiating cause of the vascular accident. Portal thrombosis occurred sixteen times, to account for an equal number of occlusions, while diseases of the liver, with or without splenic and pancreatic lesions, contributed to the initiating causes of thrombosis in a number of patients. Blood dyscrasias (polycythemia vera) accounted for the thrombosis of the mesenteric veins in three patients. Pelvic inflammatory disease may contribute to the etiology of venous occlusion, but of all such cases it is uncommonly associated with thrombus formation in the mesenteric vessels. Acute phlebitis in peripheral veins may cause the mesenteric lesions. Other degenerative diseases may cause venous occlusion. It was found in this survey that 99 per cent of the occlusions occurred in the superior mesenteric vein, while only the patients with this vein alone involved recovered from the accident. Patients having hepatic, splenic, pancreatic or portal involvement invariably died, and those without any associated lesions to account for the thrombosis were most likely to survive.

An attempt was made to determine the relationship of the extent of the involved mesentery and intestine to the ultimate outcome of the patient. There were twenty-two out of the thirty-three patients who recovered in whom only the ileum was involved, while five involved the jejunum alone, and in four a portion of both these segments showed the effects of the occlusion. In one patient, the veins were occluded, but it was stated that the bowel was not involved. Still another was reported to have the entire jejunum and ileum involved; this patient survived after



a resection. Flint, as quoted by Boyce and McFetridge, showed that 50 per cent of the small bowel may be removed with recovery and normal function.

Among the seventy-one who died, twenty-two had the ileum alone involved and two involved only the jejunum; fifteen showed combined involvement of the ileum and jejunum; five involved the lower ileum and cecum; and in five some part of the colon was attacked. There were twenty-two patients in whom the small bowel was indicated as being involved but no further localization was noted. Eight patients who died from venous occlusion had the entire small bowel affected.

The thirty patients in the recovery group whose ages are known averaged 38.9 years, whereas the sixty-eight who died had a mean age of 44.4 years. This would indicate to some extent that the younger the patients are, the better the prognosis should be.

The average length of the bowel involved in twenty-two of thirty-three patients recovering was 38.1 inches. When this is compared with thirty-seven patients who died, having an average of 102.4 inches of the intestine infarcted, there is definite evidence that the prognosis depends on the extent and location of the lesion. Roughly, from these figures, it may be concluded that if no more than 36 to 38 inches of the small intestine shows venous occlusion, the prognosis is hopeful, while an amount greater than this causes the mortality rate to rise rapidly.

The general mortality rate of this series of 104 cases was 68.2 per cent. This is better than the 85 to 95 per cent commonly stated in the literature for the arterial and venous cases combined.

#### SYMPTOMATOLOGY

There is a fairly definite symptom pattern as demonstrated by the case reports and indicated by other writers on this subject. It is generally conceded that the symptoms of arterial occlusion are more fulminating while the progression in the

venous type is slower. The onset of symptoms in venous occlusion may mean an unfavorable delay for the patient and may be misleading to the diagnostician. The symptoms, physical findings, and the laboratory findings are discussed separately.

*Pain.* The onset of pain may be rapid or slow. It may be colicky in character with a disproportion of abdominal tenderness and duration of symptoms to rigidity, according to Donaldson and Stout. Whittaker and Pemberton stated that the severe pain of venous occlusion is preceded by a less severe dull ache which is more frequently constant than intermittent. All authors agree that pain is the presenting symptom. The patient of Lower and Glazer was sent to the clinic for a urologic study because the pain suggested renal colic. It was found to be 100 per cent present in the cases studied by Meyer, but he did not differentiate the pain of arterial and venous occlusion. Dunphy found that abdominal vascular pain was the result of an anoxemia of the intestinal wall and that it was a true visceral pain manifested through sensory neurones in the sympathetic nerves independently of the musculoeutaneous pathways. The contrast between the severity and persistence of the pain and the paucity of physical findings was the most significant diagnostic feature of mesenteric venous occlusion.

*Vomiting.* Whittaker and Pemberton write that vomiting is more frequent in arterial occlusion, and that in 50 per cent of the combined venous and arterial cases vomiting occurred. The pure venous lesion should present this symptom less frequently. Vomiting did not occur in the case reported by Mallory in which 3 or 4 feet of bowel was resected, with recovery. Warren and Eberhard considered vomiting to be a highly diagnostic point and of some value prognostically, for it generally occurs rather late and is likely to indicate a lesion high in the jejunum, large in extent, and not amenable to surgery. Meyer listed vomiting as definitely occurring in 55 per cent of ninety-two cases of mesenteric



vascular occlusion. Gambee stated that in his case involving the inferior mesenteric vessels, vomiting did not occur, but claimed that vomiting is as frequent and copious as in other forms of acute intestinal obstruction, and that blood in the vomitus suggests mesenteric vascular occlusion. Mathews remarked that when hematemesis occurs the chances of recovery are poor. Boyce and McFetridge found that vomiting tends to diminish after six to eight hours when the stomach and intestines are emptied. They found peristalsis is reversed only above the lesion while in the involved area there is no peristalsis in either direction.

**Bowel Function.** Constipation was considered by Whittaker and Pemberton to be more common than diarrhea, and blood was noted more often in cases of venous thrombosis (37 per cent). Gambee and Warren and Eberhard, with others, considered diarrhea and melena as differential points in obstructions with and without interference to circulation. Meyer found that diarrhea occurred in 10 per cent of both the venous and arterial types. Klein designated one of his groups as the diarrheal group, with an incidence of 15 per cent. Brown considered hematemesis to be less frequent than melena and quoted Reich as stating that 41 per cent showed diarrhea and that 20 per cent showed blood in the stools. Donaldson and Stout stated that occult blood is uniformly present in the stools, and the bowel movements continue dark and soft to liquid in nature. Boyce and McFetridge considered tenesmus to be the more usual form of disturbed bowel function.

**Distention.** This symptom and sign is considered by most writers to be a late manifestation and is not relieved by bowel movement or enemata. Its occurrence may then be considered a grave prognostic sign.

**Shock.** There is unity with the opinion of Boyce and McFetridge that shock, which is marked in fulminating cases, is in other cases proportional to the degree of mesenteric involvement.

#### PHYSICAL FINDINGS

**Temperature.** The temperature at the onset is either normal or subnormal, but within a few hours may rise to 101° or 103°F.

**Pulse.** The pulse rate may be slow at the onset but varies with the temperature and degree of shock. In severe shock it may be rapid and thready in character.

**Pallor.** Those patients with a rapid onset and very severe pain will show varying degrees of pallor but the patients with venous thrombosis and a slow insidious onset may show no complexion changes until the occlusion becomes complete and the epigastric pain is severe.

**Tenderness.** All writers agree that tenderness is much less than expected in proportion to the pain and extent of the lesion. There is general abdominal tenderness without localization, especially in the venous cases, until the occlusion becomes complete. The tenderness in these advanced cases then tends to be epigastric.

**Rigidity.** This physical finding is generally lacking in the early cases, but as the lesion advances it becomes more definite as the parietal peritoneum becomes irritated. This sign may be of great differential value in eliminating other possible lesions, such as perforated ulcer of the duodenum or stomach, appendicitis, pancreatitis, and acute cholecystitis. The costal excursions may give the best index as to the presence or absence of rigidity.

**Palpable Mass.** Although a mass has been reported to be palpable in some cases, this cannot be depended upon for any aid in diagnosis.

**Peristaltic Sounds.** Those patients in whom only a portion of the bowel is involved may on auscultation show some sounds present. They are not likely to be so loud and gurgling as in cases of mechanical obstruction, but when the entire small bowel is affected by the thrombotic process, absence of peristaltic sounds is the rule, and distention is more likely to occur.

## LABORATORY FINDINGS

*Bloody Stools.* There may be no evidence of gross blood in the stools but laboratory testing would undoubtedly show its presence more often than is reported. Some writers agree that this is a very diagnostic procedure.

*Leucocytosis.* At the onset the white blood count may be normal, but as the lesion progresses, leucocytosis is the rule. Whittaker and Pemberton found that the range of the blood count for venous thrombosis is 20,000 to 27,000. Polymorphonuclear predominance occurs as the count rises.

*Roentgenographic Interpretation.* The zero film of the abdomen could be expected to show evidence of intestinal obstruction in a large percentage of cases. It would be logical to state that the more advanced the occlusion at the time of the Roentgen examination the more clear cut the obstruction would be. Fluid levels could be expected with overlying gas.

## CASE REPORTS

**CASE I.** A white Austrian male 52 years old complained that three weeks before his hospital admission January 6, 1939, pain developed in his left upper abdomen following an alleged strain while at work on a W.P.A. project. The pain was sharp and stabbing at the onset but became constant and dull with occasional superimposed sharp stabs. He had slight hematemesis the day after the injury but denied any other gastrointestinal symptoms other than an occasional unexplained diarrhea during the past year. During the first night of hospitalization, the epigastric pain became sharp and colicky and spread throughout the abdomen. This was followed by hematemesis of bright red blood and bowel movements containing large amounts of unclotted blood. In about eight to ten hours, distention began to develop. His past medical and family histories gave no aid in the diagnosis.

Physical examination showed a white asthenic male apparently quite ill. The sclera showed a suggestion of jaundice. The lungs were clear except in the left lower lateral chest where there was percussion dullness. The heart was normal in size with normal sounds. Blood

pressure was 150 systolic and 80 diastolic, while the pulse was regular at a rate of 100. There was tenderness and distention of the abdomen with limitation of epigastric excursions. Tenderness was acute in the left upper quadrant and epigastric rigidity was present. The liver and spleen were not palpable, but there was a reducible right indirect inguinal hernia. Temperature on admission was 98.4°F., but dropped to 97.2°F. after the onset of acute pain. The blood count on admission was: 90 per cent hemoglobin; R.B.C. 4,720,000; W.B.C. 9,350 with 83 per cent polymorphonuclears, 15 per cent lymphocytes, and 2 per cent eosinophiles. The urine was negative except for a trace of albumin. From these data a clinical diagnosis of acute intestinal obstruction was made.

A zero film of the abdomen showed many loops of distended small intestine arranged in the herringbone pattern and presenting various fluid levels. Pneumoperitoneum was not present.

A laparotomy was performed showing hemorrhagic infarction of the entire small bowel, except for 6 inches of the jejunum and 10 to 12 inches of the distal ileum, and the peritoneal cavity contained large amounts of serosanguineous fluid. The spleen was enlarged to six times normal size, while the liver was more firm than normal to palpation. The mesentery throughout was edematous, pale, and contained hard palpable nodules. An enterostomy was performed in the lower ileum and the abdomen was closed.

Death occurred about four hours after operation and autopsy showed marked cirrhosis of the liver, Banti's type splenomegaly (on microscopic section), extensive thrombosis of the superior mesenteric vein and its branches, and hemorrhagic infarction of nearly all of the small bowel. The mesentery was thickened, nodular, and immobile. The superior mesenteric artery, and splenic and portal veins were free of thrombi. There was no endocarditis nor arteriosclerosis.

This case represents a typical venous occlusion with the usual slowly progressing onset climaxed by severe pain associated with nausea, vomiting, bloody diarrhea, and characteristic laboratory and roentgenologic findings. This case supports the statistics from the study of 104 cases.

**CASE II.** A female, aged 57 years, was admitted to the Robert Packer Hospital on January 2, 1937, with a history that, on the

previous day, after a long automobile trip, she began to have a colicky pain throughout her abdomen. The pain continued during the night and she vomited repeatedly. On the day after her illness began, the pain localized to the right lower abdomen and the vomiting continued despite the absence of distention. Her bowels moved normally. This patient had no previous similar attacks and her family history was irrelevant.

A physical examination showed the patient to be in some distress, temperature 98.4°F. and heart rate 96 with regular rhythm. The blood pressure was 144 systolic and 86 diastolic. The abdomen was tender in the right lower quadrant, with some rigidity but no distention.

Laboratory studies showed the hemoglobin to be 84 per cent; R.B.C. 4,000,000, W.B.C. 9600, with 96 per cent polymorphonuclears and 4 per cent lymphocytes.

An appendectomy for acute appendicitis was performed approximately twenty-six hours after the onset of the illness. The peritoneal cavity contained excessive amounts of turbid fluid. Further exploration showed 72 inches of lower ileum to be hemorrhagic, and the involved segment was resected with repair by lateral anastomosis. Her postoperative course was stormy with temperature ranging between 101.8°F. to 105°F. and the pulse rate varied between 130 and 150. Oliguria developed on the fifth postoperative day despite the daily administration of saline and glucose, and death occurred on the seventh postoperative day.

The autopsy report confirmed the surgical findings of venous occlusion near the base of the mesentery but no extension had occurred postoperatively. The enterostomy and anastomosis had not leaked.

To the author, this case represents a typical mesenteric venous occlusion with a relatively short period of onset. The etiologic factors concerned were probably the acute appendicitis and the age of the patient.

**CASE III.** A male, aged 67 years, came to the Robert Packer Hospital on December 12, 1938, complaining that he had been awakened from his sleep by epigastric pain. Immediately after breakfast his pain became more severe but did not radiate, and he vomited twice. After a hypodermic of morphine, he was referred to the hospital. His past medical and family histories were irrelevant.

Physical examination showed the pulse rate to be 72 and his admission temperature was

96.6°F. Tenderness with slight rigidity was present over the McBurney area but there were no masses or distention. The heart was enlarged to the left with a diastolic murmur at the apex and aortic areas. Blood pressure was 210 systolic and 140 diastolic. An easily reducible indirect inguinal hernia was present on the left side.

Laboratory studies showed the urine to have only a faint trace of albumin; W.B.C. 10,000 with 88 per cent polymorphonuclears and 12 per cent lymphocytes. Two and one-half hours after admission, the leucocyte count was 18,200, with 97 per cent polymorphonuclears and 3 per cent lymphocytes. A clinical diagnosis of acute appendicitis was made and operation was advised but the patient refused surgery. Five hours later the white blood count reached 20,900 and the differential count was 92 per cent polymorphonuclears and 8 per cent lymphocytes. At this time the red cells numbered 5,200,000 and the hemoglobin was 103 per cent. The abdominal pain persisted with the pulse rate rising to 100 and the temperature was 97°F. Finally, the patient accepted surgical advice but during operative preparation, the pulse rate increased to 130 and was very weak. His blood pressure dropped to 80 systolic and 60 diastolic. In view of this rapid change of condition, the lesion was considered to be a coronary occlusion and not appendicitis, with consequent return of the patient to his bed without operation. The shock increased and death occurred approximately twenty-three hours after the onset of the illness.

Post-mortem examination showed that the peritoneal cavity contained a large amount of thick bloody fluid. The proximal jejunum for about 1 meter, and the distal half meter of the ileum were normal while the intervening small bowel was hemorrhagic, distended and friable. The arteries of the mesentery were patent and the veins were filled with ante-mortem clots. The heart was enlarged and showed severe coronary sclerosis. The final diagnosis was venous mesenteric occlusion.

This was a typical case with subnormal temperature, epigastric pain, vomiting, progressive blood changes and development of shock while the patient was under observation. However, the extent of involvement of the small gut precluded any chance of recovery even if the patient had accepted the surgical advice when he was first approached. The most important

point in the diagnosis of mesenteric vascular occlusion is to keep it in mind.

### TREATMENT

Although enterostomy has been advocated by some surgeons as the method of treating this lesion, most writers agree that primary resection of the involved portion of the intestine is the best approach to this problem. It has been pointed out that resection 3 to 6 inches on either side the area of infarction is necessary to prevent extension of the thrombosis. In those cases due to over-indulgence in alcohol, as pointed out by Ochsner, resection may not be necessary to effect a cure. In patients in whom thrombosis results from infection such as appendicitis, Jones advocates the Wilms-Braun operation of ligating the ileocecal vein to prevent the extension of the thrombosis.

### SUMMARY

About 772 cases of mesenteric vascular occlusion, including arterial and venous types, have been reported in the literature.

A statistical study of 104 cases of mesenteric venous occlusion from the literature, the Robert Packer Hospital, and from the author's experiences is presented.

Three rather typical cases of mesenteric venous thrombosis are reported.

The author wishes to express appreciation to Dr. Donald Guthrie, Chief Surgeon of the Robert Packer Hospital, Sayre, Pennsylvania, for permission to report two cases from his files and to Dr. K. W. Woodhouse, Fellow in Surgery, for his careful summaries of the cases.

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# REDUCING THE MORTALITY OF PERFORATED APPENDICITIS\*

## A STUDY OF ONE HUNDRED CASES

ARNOLD S. JACKSON, M.D., F.A.C.S. AND ROLLIN PERKINS, M.D.

Jackson Clinic

MADISON, WISCONSIN

APPROXIMATELY 170,000 persons in the United States died of acute appendicitis during the years 1928 to 1938. Year after year, regardless of the great advances in medicine, surgery, and anesthesia, the death rate of this disease continues to exceed that of thirty years ago. Occasionally, as the result of a lay educational campaign, such as the one conducted in Philadelphia, a local decrease in the death rate has occurred. Yet in 1900, the death rate for 100,000 population from this disease in the United States was 9.7; in 1936, the latest figure available was 12.8.

During this period of thirty years, countless addresses have been presented before medical societies on the diagnosis and treatment, the choice of anesthesia, and the preferred surgical technique in appendicitis. Thousands of medical papers have exhaustively covered other phases of the subject, such as the indications for immediate or delayed operation, the choice of incision, or treatment of complications. Large series of cases have been reported to demonstrate the preference of one method over another. Many of the figures quoted have dealt with cases of nonperforated, acute, subacute, and chronic appendicitis.

In this era of medicine and surgery, there should be no mortality from appendicitis except in perforated cases. True, a tragedy may occasionally result from an error in administering anesthesia, an embolism, pneumonia, coronary occlusion, diabetic acidosis, renal failure, tetanus, or even peritonitis in nonperforated appendicitis, and every experienced surgeon has prob-

ably been unfortunate enough to observe a few such cases.

People die of appendicitis today just as they did thirty years ago because the appendix is allowed to rupture. Often this is the result of unfortunate delay on the part of parents in calling a doctor, delay frequently based on ignorance or fear, delay because either husband or wife fear surgery or its expense, delay because distance or transportation prevented the physician from reaching the patient in time, or because he or the consultant failed to appreciate the seriousness of the condition. Such failures are usually inexcusable, although perhaps no experienced internist or surgeon can say that he has never been wrong in his diagnosis of appendicitis. Because the diagnosis occasionally may be puzzling and since the mortality in nonperforated appendicitis is almost negligible, it would seem advisable to operate when in doubt. Time and experience alone teach the pitfalls, such as unsuspected pneumonia, pyelitis, salpingitis, and other non-surgical conditions, which must be avoided in doubtful cases.

In any discussion of appendicitis, the results of large series of operations performed on simple acute and chronic appendicitis are of little value from a mortality standpoint. Guthrie<sup>1</sup> feels that to include uncomplicated cases in the computation of mortality in acute appendicitis is to obscure the real cause. This study, therefore, is based on a series of one hundred consecutive cases of perforated appendicitis observed over a period of fourteen years from January 1, 1924, to January 1,

\* Statistical study prepared by Rollin Perkins, M.D.

1938. Five times this number of cases could be reviewed and perhaps more could be learned, but by studying carefully a group

In spite of this fact, the condition is more serious in the male patient. Complications occurred in twenty-four of the sixty-four

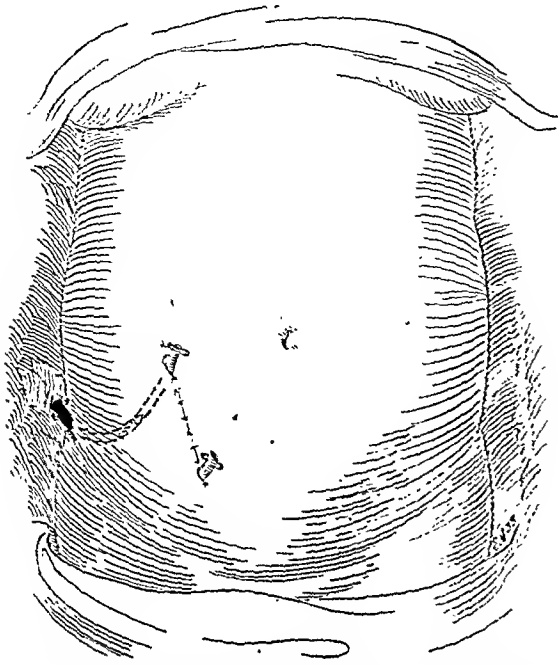


FIG. 1. Method of counter or flank drainage in perforated appendicitis with peritonitis.

this size in which the termination was fatal in twelve, many important facts about appendicitis should be revealed.

#### STATISTICAL STUDY

Of one hundred cases of ruptured appendix, sixty-four were male and thirty-six were female patients.

By referring to Chart 1, the average case is seen to be a male patient, 31½ years of age who had had symptoms for about three and two-thirds days before coming to see a doctor. The usual symptoms were epigastric pain or generalized abdominal pain, localizing in the right lower quadrant, associated with nausea, vomiting (usually once or twice), and probably either constipation or diarrhea. His postoperative course was a slow but uneventful recovery and he was discharged on his twenty-fourth postoperative day.

On the average, women wait longer than men before seeing their doctor. In this series, the average duration of symptoms in the female patient was 4.6 days, for men 3.3 days.

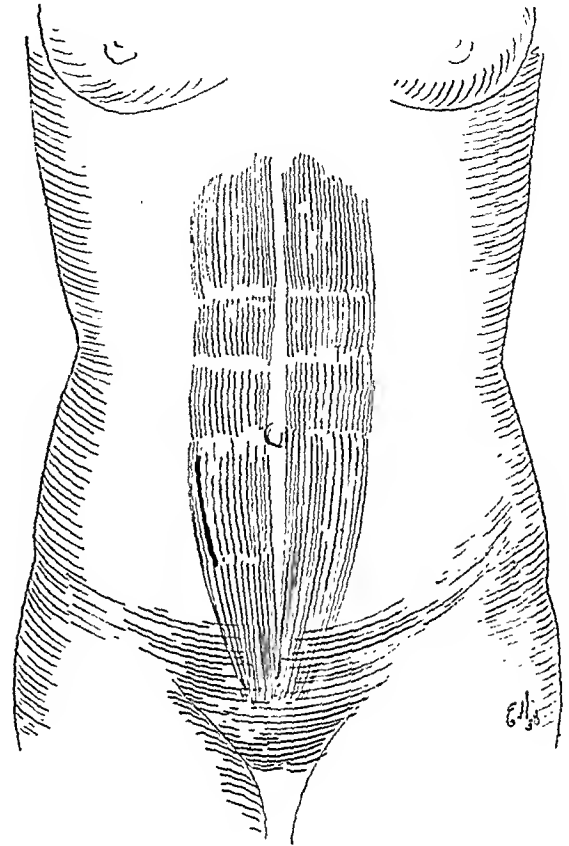


FIG. 2. Location of pararectus incision.

male patients, or in 36 per cent of the cases, but in only eight in the thirty-six female patients or 22 per cent of the cases. Furthermore, the mortality rate was lower in the female patients, probably because of the greater resistance of the pelvic peritoneum. There were ten deaths in male patients, or 15.6 per cent, in contrast to the two deaths in female patients or 5.5 per cent. This is comparable to the death rate for the United States; in 1936, 9,989 men and 6,491 women died of appendicitis.

The mortality rate in the one hundred cases was 12 per cent.

The average stay in the hospital for patients who recovered was 24.5 days, being approximately the same for both sexes. The men were discharged on the average in 24.7 days, the women in 24.3 days.

The majority of the patients (68 per cent) recovered with no complication,

including one girl who had bronchopneumonia simultaneously with her ruptured appendix. Of the thirty-two who developed complications, there were:

1. Six cases of general peritonitis, two of which were associated with intestinal obstruction, all of which terminated fatally.
2. Four cases of fecal fistula.
  - a. Two recovered.
  - b. One was associated with intestinal obstruction and died.
  - c. One was associated with repeated hemorrhages and died.
3. One case with hemorrhage from the wound—recovered.
4. Two cases of intestinal obstruction alone which recovered.
5. Four cases of wound infection all of which recovered.
  - a. One with a chronic, suppurating abdominal wound.
  - b. One with a chronically draining sinus.
6. Four cases with chest complications, all of which recovered.
  - a. One developed pleurisy.
  - b. One developed fluid in the chest.
  - c. One developed empyema.
  - d. One developed a lung abscess.
7. One case developed a subphrenic abscess and died.
8. Two cases developed thrombophlebitis, both recovered.
9. One case developed a toxemia postoperatively but recovered.
10. One case developed an abscess over the coccyx and recovered.
11. There were two postoperative hernias, both of whom recovered. One of these, a boy thirteen years of age, had a simultaneous acute tonsillitis.
12. One patient developed a pelvic abscess but recovered.
13. One developed septicemia and myocarditis and died.
14. One case, which recovered, developed abdominal distention, vomit-

ing, and hiccup for the first five postoperative days.

In Chart II, the cases are distributed throughout the age groups, bearing out the old adage that appendicitis is a condition occurring any time from the cradle to the grave. The youngest patient was 3 years of age, the oldest 75. The average age for all patients was 31½ years. The average age for male patients was 35 years, for women 25¼.

The largest number of cases occurred in the 10 to 19 year age group, and forty-two of the one hundred cases occurred in the 3 to 19 year age groups. Furthermore, the cases in these two groups had a much better prognosis, there being 26.4 per cent complications and a mortality rate of only 9½ per cent. In the very young, the general observation is that the mortality is high, due to the greater virulence of the infection, a tendency to early perforation, and a faster spread of the pathologic alterations. Diagnostic difficulties resulting in delayed operation, and the more frequent recourse to cathartics combine to give a mortality rate of 20 per cent in children under the age of three years.<sup>2</sup> In elderly patients, the mortality rate increases as in other conditions because of the frequency of diagnostic errors and decreased resistance. It is interesting that of the twelve cases in the 40 to 49 year age group, there were only 25 per cent complications.

We can draw the following conclusions from this study of perforated appendicitis.

1. It is nearly twice as common in male patients.
2. It is much more serious in male patients (complications occurring in a ratio of about 3:2 as to women and the mortality rate in a ratio of about 3:1).
3. It is more common in patients from 1 to 19 years of age and the prognosis in the 10 to 20 year age group is very favorable. In the very young this is not true.
4. The choice of anesthetic makes a very marked difference in the prognosis of the case. With spinal anesthesia but two deaths occurred in forty cases; there were six

deaths in thirty-five patients when inhalation anesthesia was used.

5. Patients wait on an average of 3.6 days before seeing their physician.

delay. All but two had taken or been given a purgative. Even the taking of castor oil or some other laxative might not have resulted fatally if operation had been per-

MORTALITY RATE FOR APPENDICITIS IN U.S.A, 1900-1936.

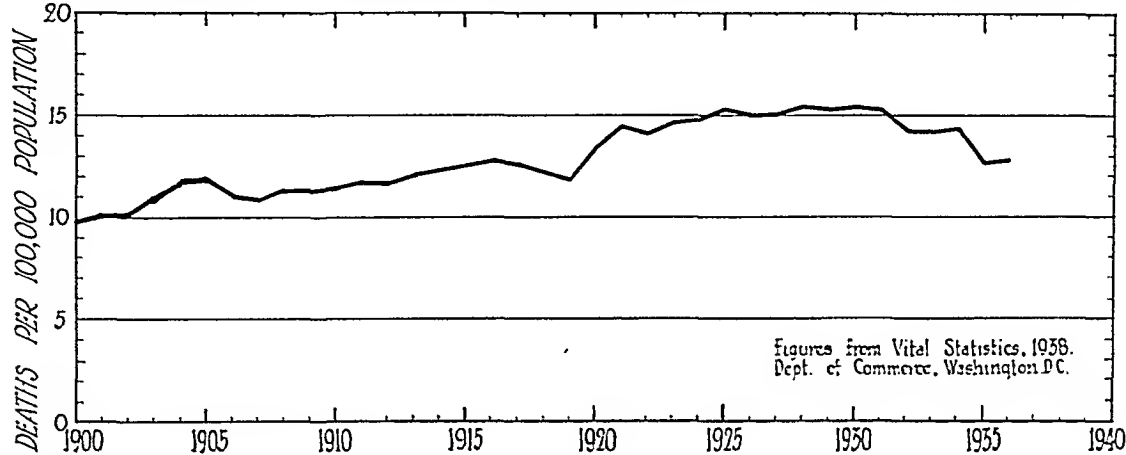


CHART I.

CASES OF RUPTURED APPENDIX AT JACKSON CLINIC

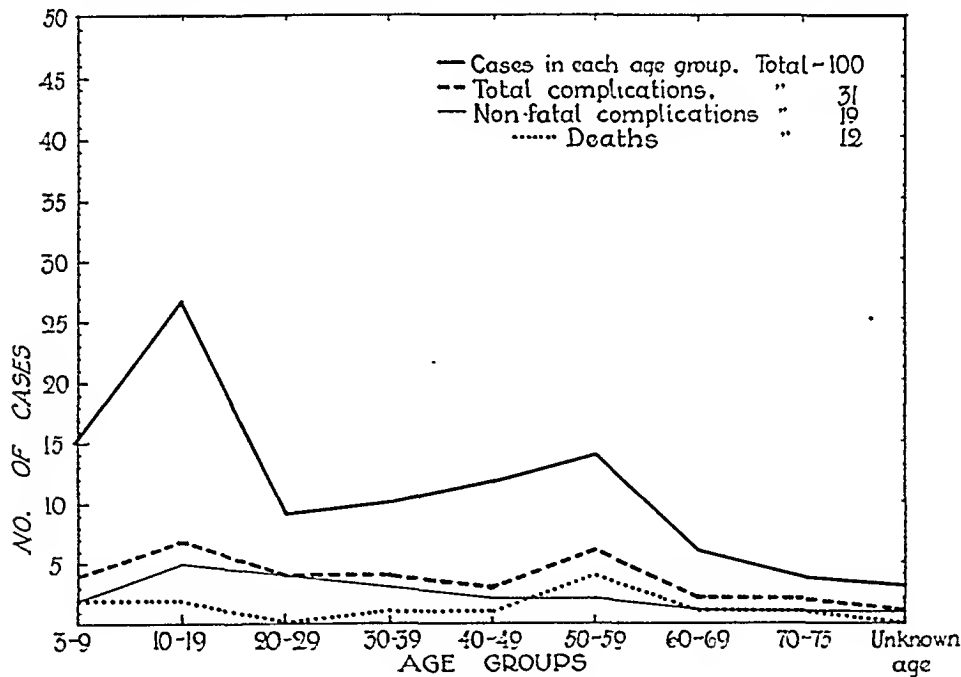


CHART II.

Garlock<sup>3</sup> has pointed out that the mortality rate of acute appendicitis is directly dependent upon the length of time between the onset of symptoms and operation.

FACTORS THAT WILL DECREASE MORTALITY

Eighty-one of these one hundred patients with perforated appendices and peritonitis recovered in spite of delayed surgery. Twelve lives were sacrificed to

formed sooner. In his Philadelphia study, Bower<sup>4</sup> found that in patients with appendicitis complicated by spreading peritonitis who had taken a laxative, the chance of recovery was only one in seven. Purgatives, perforation, and peritonitis lead to death in appendicitis and this fact must be impressed upon the laity if the mortality rate is to be lowered. The place to begin is in the schools.



Why was the death rate of perforated appendicitis in the United States higher in 1936 than in 1900? One explanation is that thirty years ago appendectomies were performed largely by a few skilled surgeons. Today too many appendectomies are done by physicians who have had little surgical training and inadequate postgraduate study. Interns are often deceived by the rapidity and skill with which an experienced surgeon removes an appendix, and after a year's training, they feel qualified to operate for appendicitis. Occasionally the removal of a gangrenous retrocecal appendix may be a difficult problem for even a skilled surgeon and the question of what to do in the presence of a perforation is not a decision for the inexperienced surgeon to decide. Hertzler<sup>5</sup> feels that the operation for acute appendicitis taxes the resources of the surgeon more than any other common lesion within the abdomen.

If the mortality rate for appendicitis is to be lowered in this country, a correct diagnosis must be arrived at in a higher percentage of cases before perforation has occurred. There is nothing new in this assertion—it has been made over and over since the late nineties. However, because a patient has a normal leucocyte count, a normal temperature, or only slight abdominal tenderness, cases of retrocecal gangrenous appendicitis are continually being overlooked and allowed to perforate. An enterolith impacted in the base of an appendix may exert such pressure on the arterial supply as to result in early, complete death of all its tissues. Cessation of pain, local tenderness, and rigidity result. Leucocytosis and other symptoms of inflammations may be lacking because, without a blood supply, there is no inflammatory reaction; there is simply gangrene as in a completely strangulated hernia. Usually there is an elevation of either the white blood count or the temperature in such cases, but failure to elicit tenderness is often typical, especially in fleshy persons. In this series of cases, the examining physician was not infrequently misled by

this failure, with the unfortunate result that operation was delayed too long. A most helpful method to recognize early these deceiving cases of retrocecal appendicitis is to place the patient on his left side with his knees drawn up, have him take a deep breath, and at the end of expiration, deeply palpate at McBurney's point or higher. If the appendix is retrocecal and acutely inflamed, this pressure will elicit pain. In spite of other negative findings, our experience and judgment must be the determining factor in deciding upon the advisability of operation.

A survey by the Metropolitan Life Insurance Company showed that the highest death rate for appendicitis in this country was in the Rocky Mountain and mid-western states. The only explanation offered for this is the great distances that patients must be transported. This interesting conjecture arises: Will the building of many small town hospitals so shorten the distance of transportation, thereby lessening delay, as to offset the advantage of the larger medical centers and the more experienced surgeon?

The introduction of the routine use of spinal anesthesia at the Jackson Clinic in 1928<sup>6</sup> proved to be a definite factor in lowering the mortality for appendicitis. In this series of one hundred perforated appendices, seven complications occurred in thirty-three patients when nitrous oxide and ether were used, with six deaths. There were fourteen complications in forty patients when spinal anesthesia was used, with only two deaths. Many reasons could be given to show why its routine use has decreased the death rate for appendicitis, but from an experience of sixteen years, the first six of which were spent operating with inhalation, and the last ten with spinal anesthesia, the following comparison may be made: In perforated appendicitis, shock is minimized, the operation is simplified, and fatal postoperative complications are decreased under the latter. When the abdomen is opened, the intestines are quiescent and contracted under

spinal anesthesia, and the appendix may be quickly and easily located and removed with very little spreading of infection. Occasionally, when it is necessary to use inhalation anesthesia, as in some children, it seems like turning the calendar back ten years in the history of surgery. In our experience, spinal anesthesia has definitely contributed to lowering the mortality rate for appendicitis, no deaths having occurred at the Jackson Clinic from the years 1931 to 1938 inclusive.

Statistics have been quoted to show both that it is advisable to operate immediately in all cases of perforated appendicitis or that the delayed, so-called Ochsner method, is preferable. It does not seem desirable to advocate any inflexible set of rules regarding the treatment of this condition; rather each case should be considered a special problem. Undoubtedly few surgeons would advise immediate operation in a case of appendicitis perforated for three or four days with resulting spreading peritonitis, toxemia, and dehydration. Nor do many surgeons advocate the use of an ice bag and morphine when the perforation is a few hours old. It has been our experience that whenever possible it is better to operate as soon as the patient's condition permits and to remove the appendix rather than merely establish drainage. If, however, perforation is days old and either spreading peritonitis or localizing of an abscess is occurring, immediate operation is contraindicated. In such instances, the time of operation must be determined by the individual case. It may be a question of days, weeks, or even months.

A great deal has been said and written about the type of incision and how it may affect the end result of operation. Reid,<sup>7</sup> as well as many other surgeons, feel that there is definitely a lower mortality rate when the McBurney rather than the right rectus incision is used. Whether the McBurney, the pararectus, or right rectus incision is used has been of no great consequence in our experience since they have all been employed with the same results.

When the diagnosis of acute appendicitis is apparent, and the appendix is not too difficult to remove because of abnormal location, the McBurney incision is ideal. As we may be mistaken in our diagnosis of an acute surgical abdomen and because the appendix is often not at McBurney's point, the exposure obtained by this incision is not ideal. It is not to be compared with that obtained by the pararectus incision in which the rectus muscle is withtracted toward the median line, nor have any cases of postoperative hernia resulted. I believe one of the reasons why Starr Judd was a great surgeon was because of the remarkable exposure he obtained in operating, making his operations seem simple by comparison. He showed the fallacy of small incisions and inadequate exposure in abdominal surgery. Because there is less bleeding and trauma in the pararectus incision, we have, for the past ten years, preferred this incision to the right rectus in operating for appendicitis. Where it is undesirable to break down adhesions and spread infection as in a localized abscess, the McBurney incision may be preferable.

In cases of ruptured appendicitis treated surgically, the question always arises as to the advisability of removing the appendix or merely to drain. It has been our policy to remove the appendix unless an abscess was so localized that its attempted removal might result in too much trauma and spread of infection. This was true in only three of the cases in this series. In surgery as it was practiced a quarter of a century or more ago, when the patient came to operation badly dehydrated and was then drugged with ether, the time spent on the operating table might have been a deciding factor against removal of the appendix. Today, with intravenous therapy, spinal anesthesia, and duodenal drainage in common use, time is not such an important element in the lowering of mortality.

The question of drainage is of the greatest importance in the prevention of postoperative complications and lowering

the death rate for appendicitis. Of the one hundred cases in this series, thirty were operated upon by one of us (A. S. J.) and there was only one fatality in a case of generalized peritonitis, and no serious postoperative complications. The absence of postoperative pneumonia, subphrenic or other abscesses, fecal fistula, intestinal obstruction or other sequelae may be attributed to good fortune, a small series of cases, proper drainage, and to the early anticipation and prevention of complications.

Every case with free pus in the peritoneal cavity was drained with a cigarette drain to the site of the abscess or, if there was generalized contamination, to the pelvis. In addition, counterflank drainage was used in cases of the latter type. This procedure was, I believe, largely responsible for the non-occurrence of a subdiaphragmatic abscess. Moderately soft rubber drainage tubes were used and, most important, they were not disturbed for five or six days after their insertion unless no drainage was observed by the third day, when the drain was slightly loosened. Large, fluffy, moist dressings were applied lightly so that they would not act as a cork for the drain, but encourage drainage. Gentle irrigation through the counterdrain extending from the upper third of the incision and through a stab wound in the flank was begun on the third day. Small holes cut in the middle of this tube permitted pus to be washed out with Dakin's and saline, preventing an accumulation in this trough. The cigarette drain was gradually shortened for four or five days and then replaced by a small soft rubber tube which, in turn, was gradually removed. After seven to ten days a smaller caliber drain was sutured to the end of the counterdrain and the latter withdrawn, thus drawing the new tube in place. When this was ready for removal, a piece of chromic catgut was fastened to this tube which was in turn withdrawn. This permitted gradual closing of the infected

drainage tract without abrupt interruption and abscess formation.

The question of drainage has been discussed in detail because it is perhaps the most neglected subject in the literature and still the most important to the younger surgeon. We have had no experience in the closure of peritonitis cases without drainage. Improper drainage and too early removal of drains is a definite factor in the high mortality of this condition and to my brothers, Reginald and James, I wish to acknowledge advice and assistance especially in this respect.

There are few operative procedures in which the judgment acquired only by means of experience means more to the younger surgeon than in the care of cases of perforated appendicitis. The matter of wound closure is one that may easily confuse the novice. Gamble<sup>8</sup> was able to reduce his mortality for peritonitis due to appendicitis to 1.5 per cent by leaving the abdominal wound open to the air. He lost only two patients in a series of 129 cases, certainly a splendid record. I have not used this method and in fact have closed all wounds, although not tightly, with interrupted ligatures, leaving a free drainage space around the tubes. This method has so far proved successful and no postoperative hernias have resulted.

Early in my training, I became convinced that most postoperative complications were preventable; this was clearly shown to me by Dr. William J. Mayo, when I saw him operate in the most difficult cases month after month without the loss of a patient. More than any surgeon I have ever known, Dr. Mayo was able to anticipate complications and prevent them. He did not care so much whether we carried a stethoscope, but he always wanted a stomach tube on hand and the stomach kept empty. Dr. Judd always insisted upon withholding fluids by mouth for twenty-four to seventy-two hours or longer after an abdominal operation. The immediate adoption of these procedures did more to eliminate postoperative complications than

any other factor in my abdominal surgical cases. The advent of the Levine duodenal tube for drainage was a further step in the elimination of acute postoperative gastric dilatation, distention, ileus, and intestinal obstruction.

From Dr. Robert Coffee, I learned the importance of not allowing a patient to lie flat on his back after operation. Today we know that if a patient is so neglected he is predisposed to develop atelectasis and other pulmonary complications as well as an embolism. A properly trained intern and nursing staff can largely eliminate these complications. Twenty years ago, Dr. George Crile impressed upon me the value of digitalizing surgical patients before complications, such as venous stasis and embolism, occurred. I believe this, together with deep breathing and passive exercise and permitting the patient to be out of bed as early as possible, have accounted for the negligible occurrence of embolism in our abdominal and pelvic surgical cases.

We try to anticipate and prevent postoperative distention not only by walling off the appendix area from the rest of the abdominal cavity with moist sponges, but by handling the intestines as gently and as little as possible. Free pus is aspirated but no attempt is made to lavage the abdomen. The use of the heat cradle, duodenal suction, hypodermoclysis, and spinal anesthesia minimize distention. Since 1928, I have used morphine only for colic or an equivalent pain. In my opinion, it is contraindicated in almost all surgical conditions except for relief of pain so severe that it cannot be controlled by sedatives.

When distention became severe in two of my cases and ileostomy appeared imperative, hypertonic salt solution was used with complete success. In a 6 year old child who developed marked distention with apparent ileus on the twelfth day, 100 c.c. of a 10 per cent hypertonic salt solution was used with excellent results.

There were no deaths from postoperative pneumonia in this group of cases which is a convincing argument for the anesthetist

and the anesthetic. Spinal anesthesia has definitely reduced fatal pulmonary complications in our experience. The use of carbon dioxide inhalations and posture change have been contributing factors. Such apparent minor details as the use of a warm dry gown, the avoidance of chilling on leaving the operating table, the use of moist, warm air in the room, and oxygen whenever indicated have helped to prevent chest lesions.

Through recent studies of Boothby and others, it appears that oxygen, when used in 100 per cent concentrations, may play an important part in lowering the mortality for ruptured appendicitis. It has already been used effectively in some cases of ileus.

#### SUMMARY

In summary, it is regrettable but none the less true that in spite of all advances in medical science, the death rate for appendicitis, as apparent in the chart, is higher in the United States today than it was thirty years ago.

During this period, the number of deaths from appendicitis in this country alone has approximated the number of persons now residing in the city of Milwaukee.

The unfortunate feature of this is that, barring rare complications, the death rate from nonperforated appendicitis is almost negligible, while the death rate for perforated appendicitis may be as high as 50 per cent in series of cases.

The greatest cause of the high death rate for appendicitis is delay on the part of someone who allows the appendix to rupture. The use of purgatives and laxatives is a predisposing cause and the inexperience of some surgeons a contributing factor in maintaining this high death rate.

Even if there is delay and perforation does occur, the mortality rate can still be lower if certain complications are anticipated and properly prevented. Adequate drainage maintained sufficiently long is important.

The use of spinal anesthesia, hypodermoclysis, duodenal suction, carbon dioxide inhalations, oxygen, postural change, digitalis, and other drugs as indicated are all helpful in the prevention and treatment of complications.

In this study, a series of one hundred cases of perforated appendicitis with localized and generalized peritonitis is reported. There were twelve deaths, a mortality of 12 per cent. It is reasonable to conclude that all of these deaths might have been prevented. During a period of fourteen years in which these cases were observed, 2,215 appendectomies on cases of non-perforated appendicitis were done without a death occurring that might be directly attributable to appendicitis.

That spinal anesthesia was a definite factor in lowering the mortality is shown by the fact that of the forty cases operated upon in which fourteen complications of various kinds occurred, there were only two deaths; of thirty-three cases operated upon under gas and ether, there were seven complications and six deaths. Under local anesthesia alone the death rate was high

also, but these patients were in extremely bad condition.

If the mortality rate is to be lowered, there must be a greater distribution of facts regarding appendicitis to the lay public. There must be a wider dissemination of knowledge by postgraduate teaching regarding surgical principles in the treatment of perforated appendicitis to those surgeons who, either through training or practice, have had an opportunity to treat but few cases.

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# SPONTANEOUS REDUCTION OF ACUTE INTUSSUSCEPTION IN CHILDREN\*

## ITS INCIDENCE AND SIGNIFICANCE IN THE DIAGNOSIS AND TREATMENT OF RECURRENT INTUSSUSCEPTION

LAWRENCE GOLDMAN, M.D.

AND

ROBERT ELMAN, M.D.

Instructor in Pediatrics, Washington University  
School of Medicine

Associate Professor of Surgery, Washington  
University School of Medicine

ST. LOUIS, MISSOURI

**A**CUTE intussusception which reduces itself spontaneously, though considered an unusually rare event, is probably more frequent than is generally realized. Because it may become a source of confusion in the diagnosis and treatment of obscure abdominal symptoms in children it is of practical importance.

*Definitions.* Acute intussusception is a well defined clinical and pathologic entity; because it nearly always leads to rapid necrosis of the bowel unless relieved, the entire fatal course of the disease is usually but a matter of days. When a child is ill for weeks or months and is then found to be harboring an intussusception, many authors have spoken of the disease as chronic intussusception. Under such conditions it is hard to believe that the lesion has been present continuously during all the time; a *permanent* intussusception can certainly not be compatible with life for more than a week from the extremely rare instances when the gangrenous gut is sloughed off into the lumen and passed per rectum. Two explanations for chronicity are possible: (1) that the lesion has been partial and (2) that it has been intermittent; only the latter group will be considered in this report. Obviously, however, if the lesion is intermittent the term recurrent intussusception should be used, and such a term, of course, implies repeated attacks with spontaneous reduction of the invagination after each attack. A similar confusion in terminology is often encountered in appendiceal disease; the term

chronic appendicitis is frequently misused when it is applied to a patient with an obvious history of several previous attacks of acute appendicitis which subsided. It is more difficult in infants to obtain a history diagnostic of recurrent intussusception. However, in several cases herein reported such a history was elicited; moreover, in a few the tumor was clearly observed by palpation to appear and disappear. In the case reports in the literature, unfortunately, such a clear cut history or physical findings have not been generally described.

There is a further source of confusion in terminology which should be mentioned; the term recurrent intussusception, especially in the surgical literature, is often confined to instances recurring after operation. Thus, Thorndike,<sup>1</sup> in a paper entitled "Acute Recurrent Intussusception," refers to it only as a postoperative complication. Ladd and Gross<sup>2</sup> in a later paper also restrict this term to patients previously operated upon for intussusception. They state that ninety-three such cases have been reported in the literature; seven cases of their own are described, an incidence of 1.8 per cent. These authors use the term subacute and chronic intussusception when the duration of symptoms is over five days; they mention twenty such cases but do not describe the clinical features in detail, so that it is difficult to tell whether or not they presented intermittent manifestations of a recurrent lesion. Postoperative recurrence is not considered in this paper.

\* From the Departments of Pediatrics and Surgery, Washington University School of Medicine and St. Louis Children's Hospital.

*Incidence.* Surgeons occasionally perform a laparotomy in a child with a diagnosis of acute intussusception based upon all the characteristic manifestations including the palpation of a tumor, but find no such lesion. Careful exploration of the peritoneal cavity reveals an edema of the terminal ileum and cecum and a few enlarged ileocecal lymph nodes as the only evidence that the invagination had been present. Less puzzling to the surgeon but perhaps almost as discomfiting, is the spontaneous reduction of the lesion under his eyes just as the mass is delivered into the abdominal incision. These examples, however, while interesting, are not only rare but really have no significance in the clinical diagnosis of obscure abdominal disease in children.

At the bedside it is difficult to tell accurately how often recurrent intussusception really occurs. Stallman<sup>3</sup> who has reported the largest series of cases, observed nine among 117 children with intussusception, an incidence of 8 per cent. This author also discussed the terminology at some length and criticized adversely the use of the term "chronic" in these cases. Ladd and Gross<sup>2</sup> mention twenty cases as "subacute and chronic intussusception" among 372 cases, an incidence of  $5\frac{1}{2}$  per cent. Birkenfeld<sup>4</sup> reported 160 cases out of the literature, 109 of them in patients over 2 years of age. Other reports are summarized in Table 1. As indicated above, however, it is difficult to tell whether all of these cases were true examples of intermittent intussusception. In the experience of the present authors, five patients were observed during the past four years, a period during which twenty-seven cases of acute intussusception were admitted to the St. Louis Children's Hospital; this remarkably high incidence was responsible for making this report.

#### CASE REPORTS

CASE I. E. M., a 4 year old white female, had had many episodes apparently due to abdominal pain but had never vomited or be-

come ill. However, she was constipated and failed to gain in weight during an entire year. Twenty-four hours before admission she again complained of slight abdominal pain but examination was negative; the mother stated, however, that blood in the stool was observed following an enema. Eighteen hours later the pain recurred and this time a mass was felt. On admission to the hospital the child was much more comfortable and the mass, at first palpable, disappeared under the examiner's hand. A barium enema went around to the cecum which was easily visualized.

The patient slept well, but the next morning again complained of abdominal pain, and the mass again became palpable. Stools showed no blood; barium enema now visualized an intussusception at about the hepatic flexure. Operation was immediately done and the mass found to involve only the distal ileum. It was easily reduced, and the appendix removed. Recovery was uneventful; there was no transient hyperpyrexia which frequently follows reduction of strangulated intestine. Since leaving the hospital the patient immediately began to gain weight and has been well since (four years).

CASE II. V. F., a 6 year old white female, one week before admission was suddenly seized with cramping abdominal pain which passed off in a few minutes. On each of the next few days similar attacks occurred but only once did she vomit. Stools were normal and contained no blood or mucus. She was kept in bed, however, and the attacks grew less severe. On the morning of admission an especially severe attack awakened her and she vomited for the second time and soon after passed blood per rectum. On her admission to the hospital a mass was felt and at operation an intussusception was found involving the cecum and ascending colon; it was easily reduced and the appendix removed. Recovery was uneventful; there was no postoperative hyperpyrexia. No further attacks occurred (three years).

CASE III. J. R., a white male infant, at three months of age developed occasional bouts of "colic" for one week, associated with normal stools. The day before admission he refused feedings and passed bloody fluid following an enema. He vomited three times. A mass was felt but disappeared a few hours later. No operation was carried out and the patient remained well for a year except for constipa-



tion; he then developed a recurrence of severe abdominal cramping, this time associated with numerous loose stools but no blood. No mass was noted and the infant recovered after two days, and has remained well (two years).

CASE IV. P. J. R., a 23 month old white female, was admitted because she had vomited persistently for twelve hours, had severe abdominal pain and presented a large ileocecal mass on abdominal palpation. On her admission to the hospital the presence of the mass was confirmed by one observer, but later was definitely gone. An enema was returned with blood-streaked mucus. No further vomiting or abdominal pain occurred and the patient was discharged in two days. She has been well since, with no recurrence of bowel disturbance (two years).

CASE V. E. R., a 19 month old white female, listless and ailing for two weeks, was given a "round of calomel" followed by castor oil, resulting in several loose stools. For a week the baby seemed well except for frequent desire to pass stool. One week before admission she began to have short attacks of restlessness and screaming, drawing her legs up into the air, vomiting occasionally. Various home remedies were given, including further cathartics, but the attacks became more frequent. The day of admission a physician was called who felt a mass in the abdomen, considered it to be a tumor of the right kidney and sent the patient into the hospital.

On admission an abdominal mass was felt but it diminished definitely in size under the palpator's hand. Rectal examination was negative and three large semi-liquid stools were passed without blood. The patient was dehydrated and was given parenteral fluids; she fell asleep and by the next morning the mass was gone. Several loose stools were passed during the day, none exhibiting blood. By evening, i.e., twenty-four hours after admission, the mass became definitely palpable again and operation was carried out. An intussusception was found involving the terminal ileum and proximal colon; it was easily reduced and the appendix removed. The postoperative course was uneventful except for a transient hyperpyrexia. She has remained well up to the present time (two years).

*Discussion of Present Findings.* Besides the five cases described above, thirty cases

were collected from the literature although they obviously represent only a part of the many reported. They serve, however, to indicate the main clinical features which are tabulated in Table 1. Of especial interest is the frequency of diarrhea; ordinarily this symptom serves to detract from a diagnosis of intestinal obstruction. Yet, by the occurrence of a repeated invagination it is easy to see how an edema of the intestinal wall could occur with the production of an irritative inflammation resulting in diarrhea. In the five cases reported above, however, diarrhea was present in only two. It should also be noted that blood in the stool, while present in most cases, was absent in over one-third of them. Of interest is the fact that not all cases gave a clear history of intermittent attacks of abdominal pain; vague manifestations such as listlessness, constipation, frequent desire to pass stool, failure to gain weight, and anorexia were often noted.

Of therapeutic importance is the fact that operation resulted in cure of those patients that survived. That a manual reduction at laparotomy should tend to prevent recurrence is possibly explained by the serosal trauma resulting in the laying down of adhesions. If this is true it is undoubtedly more advantageous also to perform an appendectomy when the patient's condition permits, certainly at least in those lesions involving the ileocecal valve. Of the five cases described above, appendectomy was performed in each of the three operated on. In the remaining two cases, operation was not carried out because the attacks of intussusception rapidly subsided. Operation would seem the safest procedure, however, unless the clinical manifestations, including the palpation of the mass, definitely disappear within an hour or two. In many patients, on the other hand, the physician may always examine the child after the attack is over, fail to find a mass and thus remain in the dark as to the diagnosis. The problem of therapy in such a case is especially difficult, particularly in regard to the question of



TABLE I  
SUMMARY OF CASES FROM THE LITERATURE

Author	Age (Years)	Duration of Symptoms (Weeks)	Mass	Blood in Stool	Diarrhea	Operation	Result	Remarks
Mayo <sup>5</sup> .....	3½	5	o	o	o	Resection	Well	Distention and generalized tenderness.
Epstein <sup>6</sup> .....	2	12	+	+	?	Reduction	Well	X-ray showed obstruction.
Alexander <sup>7</sup> .....	4	2	+	+	o	Reduction and appendectomy	Well	Diagnosis made only on palpation of mass.
Still <sup>8</sup> .....	1	6	+	o	o	Reduction	Well	Diagnosed tuberculous peritonitis.
Still <sup>8</sup> .....	2	4	+	+	+	Reduction	Well	Diagnosed tuberculous peritonitis.
Still <sup>8</sup> .....	1	4	+	+	o	Reduction	Well	Diagnosed tuberculous peritonitis.
Still <sup>8</sup> .....	3	3	+	+	o	Reduction	Well	Diagnosed tuberculous peritonitis.
Spencer <sup>9</sup> .....	7	16	+	?	+	Laparotomy	Died after operation	Treated as tuberculous peritonitis.
Owen <sup>10</sup> .....	6	3	+	o	o	Reduction	Well	Mass noted only before operation.
Marsh <sup>11</sup> .....	2	10	o	+	o	Ileocolostomy	Well	
Marsh <sup>11</sup> .....	3	10	o	o	o	Reduction and appendectomy	Well	
Beaven <sup>12</sup> .....	3	4	o	o	o	Reduction	Well	Meekel's diverticulum.
Beaven <sup>12</sup> .....	5	2	o	o	o	Reduction	Well	
Donovan <sup>13</sup> .....	1	8	+	+	o	Reduction	Well	
Salley <sup>14</sup> .....	1	4	+	+	+	Reduction	Well	
Sutherland <sup>15</sup> .....	3	8	+	o	o	Reduction and appendectomy	Well	Diagnosed tuberculous peritonitis.
Henderson <sup>16</sup> .....	1	7	o	+	+	Reduction	Well	Operation at third attack.
Stallman <sup>3</sup> .....	3¼	8	+	+	o	Reduction	Well	
Stallman <sup>3</sup> .....	11	12	+	+	+	Reduction	Reurrence	Reoperation for colopy.
Stallman <sup>3</sup> .....	5	9	+	+	+	Reduction and appendectomy	Well	
Stallman <sup>3</sup> .....	7	12	+	o	+	None	Died	Diagnosed tuberculosis. Autopsy: perforation of intussusception with general peritonitis.
Stallman <sup>3</sup> .....	7	13	+	+	+	Laparotomy	Died	Considered tuberculosis. Autopsy: perforation of intussusception with general peritonitis.
Stallman <sup>3</sup> .....	1½	5	+	+	+	Reduction	Well	
Stallman <sup>3</sup> .....	¾	3	?	+	+	Resection	Died	Two hours after operation.
Stallman <sup>3</sup> .....	8	2	?	o	+	Reduction	Well	Died in four months of general peritonitis.
Stallman <sup>3</sup> .....	2	3	+	+	+	Reduction	Well	
Jones <sup>17</sup> .....	¾	4	o	+	+	Ileocolostomy	Died	Few hours after operation.
Jones <sup>17</sup> .....	1	1	+	+	o	Reduction	Well	
Jones <sup>17</sup> .....	9	2	+	o	o	Reduction	Well	
Jones <sup>17</sup> .....	5	6	+	o	o	Reduction	Well	
Case I.....	4	?	+	o	o	Reduction and appendectomy	Well	Rapid weight gain after operation.
Case II.....	6	1	+	+	o	Reduction and appendectomy	Well	
Case III.....	¼	1	+	+	+	None	Well	
Case IV.....	2	1 day	+	+	o	None	Well	
Case V.....	2	2	+	o	+	Reduction and appendectomy	Well	

operation. Careful abdominal examination during the attack should, however, in nearly all cases reveal the true nature of the lesion. If no mass is present, unless the attack has been recent exploratory laparotomy may reveal little; it should be emphasized, however, that a mobile cecum with a long persistent mesocolon is a suggestive finding. Waugh,<sup>18</sup> in 1911, called attention to this defect in rotation as a probable etiologic factor in intussusception. The present authors have always noted such a finding in these cases. If operation is carried out, appendectomy, as already mentioned, seems definitely an advantage, provided the patient is in good condition. It is of interest to note that in none of the postoperative recurrences described by Thorndike<sup>1</sup> was this procedure done.

#### SUMMARY

Five cases of acute recurrent intussusception in children are described in which spontaneous reduction occurred after one or more attacks. In three patients operation was carried out, the intussusception reduced and the appendix removed; in two no operation was performed. Clinical cure was observed in all cases with no further attacks for a significant interval.

Analysis of these cases, as well as of thirty others culled from the literature, emphasizes the importance of recurrent intussusception as a cause of obscure abdominal complaints in children. The clinical manifestations, terminology, diag-

nosis and treatment have been briefly discussed.

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# THE POSTOPERATIVE CONCENTRATION OF BILE SALTS IN HUMAN BILE\*

CARL H. GREENE, PH.D., M.D., F.A.C.P.,

Associate Clinical Professor of Medicine, New  
York Post-Graduate Medical School,  
Columbia University

RICHARD HOTZ, M.D.,

Junior Assistant Surgeon, Dispensary Service, New  
York Post-Graduate Medical School, Columbia  
University

R. FRANKLIN CARTER, M.D., F.A.C.S. AND

Associate Clinical Professor of Surgery, New York  
Post-Graduate Medical School, Columbia  
University

J. RUSSELL TWISS, M.D., F.A.C.P.  
Assistant Clinical Professor of Medicine, New  
York Post-Graduate Medical School,  
Columbia University

## NEW YORK CITY

A WIDE range of functional investigations has been undertaken in an attempt to determine the degree of functional hepatic damage present in a given patient, but of all the functions ascribed to the liver only one has been proved to be exclusively and specifically characteristic of that organ. This is the synthesis and secretion of the soluble salts of the various bile acids (Foster, Hooper, and Whipple<sup>1</sup>).

Experimental studies of the secretion of these bile salts have indicated that a multiplicity of factors is involved in determining their concentration in the bile secreted by an individual liver. These factors have been studied extensively in experimental animals by Stadelmann,<sup>2</sup> Whipple,<sup>3</sup> McMaster, Broun and Rous,<sup>4</sup> Rous,<sup>5</sup> Greene and Snell,<sup>6</sup> McGowan, Bollman and Mann,<sup>7</sup> Doubilet,<sup>8</sup> and many others. Similar studies have recently been made on human fistula cases in this country by Greene, Walters and Fredrickson,<sup>9</sup> Sterner, Bartle and Lyon,<sup>10</sup> Ravdin, Johnston, Riegel and Wright,<sup>11</sup> Breusch and Johnson,<sup>12</sup> Kohlstaedt and Helmer,<sup>13</sup> Doubilet,<sup>14</sup> Gray, Butsch and McGowan,<sup>15</sup> and by Gray, McGowan, Nettrour, and Bollman.<sup>16</sup> These investigators dealt with the secretion of bile salts and acids by the liver in patients following the insertion of a T-tube and drainage of the common bile duct. The conclusions shared in common by most of these investigators will be

discussed in the consideration of the results in this study.

We wish to report our experiences in the determination of the concentration of bile salts in fistula cases and to analyze the effect on the concentration of bile salts in the bile of (a) liver disease; (b) infection, including cholangitis and fever of any origin; (c) anesthesia and operative trauma; (d) dextrose administration; (e) bile refeeding and the administration of bile salts; and (f) the concentrating ability of the common duct itself.

Daily determinations of the concentration of bile salts and cholesterol and of the pancreatic ferments were performed on the bile of forty-seven consecutive patients who had operative biliary fistulae. All bile was secured by means of T-tube drainage of the common bile duct. Microscopic examination of the biliary sediment was routinely performed. The bile was cultured where an indication was present. All the tests were performed on operative bile specimens secured by aspirating the common bile duct before it was opened. Hourly determinations of the concentration of bile salts were frequently performed to determine variations in the concentration of bile salts through the day and following specific therapeutic measures. The bile salts were determined by the Aldrich-Bledsoe method,<sup>17</sup> the cholesterol by the Lieboff method,<sup>18</sup> and the ferments by the methods described by Myers and Fine.<sup>19</sup>

\* From the Clinic for the Study of Diseases of the Liver and Biliary Tract, Departments of Medicine and Surgery, of the New York Post-Graduate Medical School and Hospital.

We are not reporting the total volume of bile and therefore the total output of bile salts, for a total biliary fistula seldom occurs following the insertion of a T-tube. Such data at best would represent only an approximation.

**Hepatic Damage.** A decrease in the capacity of the liver to secrete and concentrate bile salts apparently parallels the degree of hepatic damage (Bollman and Mann<sup>20</sup>). The publications of Greene, Walters and Fredrickson, Ravdin, Johnston, Riegel and Wright, and of Gray, McGowan, Nettrour, and Bollman substantiate this observation. Ravdin and his associates found that the bile salts invariably were absent in bile following complete biliary obstruction for a week or more and that a considerable time was necessary for their reappearance after the relief of obstruction. He also reported a parallel between the concentration of bile salts in fistula bile and the degree of hepatic damage present at the time of operation. Gray, Butsch, and McGowan also studied the effect of anesthesia, various operative procedures, and postoperative treatment on the concentration of bile salts and found that the latter was inversely proportionate to the degree of hepatic damage.

We have attempted a similar study based upon the degree of hepatic damage as determined both by the preoperative clinical condition of the patient and by the appearance of the liver at the time of operation. In Table 1 the patients have been grouped according to this evaluation of the degree of hepatic damage and this factor has been compared to the concentration of the bile salts found in the common duct at operation, the rapidity of the postoperative return of the bile salts in the bile to a concentration within the lower limits of the normal range,\* the proportion of subjects in which there was not a return to a low normal concentration of bile salts during the period of drainage, and the concentration of cholesterol in the drainage bile. Table 1 confirms the observations of Gray, McGowan, Nettrour and Bollman.

\* 800 mg. per cent or more bile salts.

When, however, individual cases are studied in detail, no such clear cut parallelism exists, and certainly, in any given patient the concentration of the bile salts and the rapidity of their return to a normal concentration does not necessarily correspond to the degree of liver damage, nor does it indicate the functional state of that liver. An example of this is seen in the two patients (Table 1) who by all tests and by observation had a normal or nearly normal hepatic function, yet in whom at no time during the period of drainage did the concentration of bile salts approach the normal. The convalescence of these patients was so uneventful and the follow-up period so satisfactory that we do not doubt but that they have normally functioning livers. The many other factors that enter into the concentration of bile salts in fistula bile will be discussed later.

TABLE 1  
RELATION OF LIVER DISEASE TO CONCENTRATION OF  
BILE SALTS AND CHOLESTEROL IN COMMON DUCT  
DRAINAGE BILE

Hepatic Damage*	Cases	Average Operative C.D. Bile Salt Concentration, Mg. Per Cent	Day Bile Salts Returned to 800 Mg. Per Cent, Days	Number of Cases Not Returning to Normal	Average Daily Cholesterol Concentration, Mg. Per Cent
None.....	11	1600	5	2	50
Mild.....	14	1200	5	2	62
Moderate....	18	570	8	8	50
Severe.....	4	Trace in 2		3 (1 on twelfth day)	30 (2 had none at any time)

\* As determined by history, function tests and by operative findings.

In general those patients with severe hepatic damage, especially those with complete extrahepatic obstruction of the biliary tract had no bile salts or only a very low concentration thereof in operative bile specimens. Contrary to the findings of Ravdin, Johnston, Riegel, and Wright these livers secreted bile salts shortly after removal of the obstruction, though the ability to secrete bile salts in normal concentration was regained by only one patient during the period of drainage. These

studies on the influence of hepatic damage upon the concentration of bile salts do not lend themselves to statistical analysis. We, they had some slight degree of hepatic involvement. These cases are, however, those in which by history and by laboratory

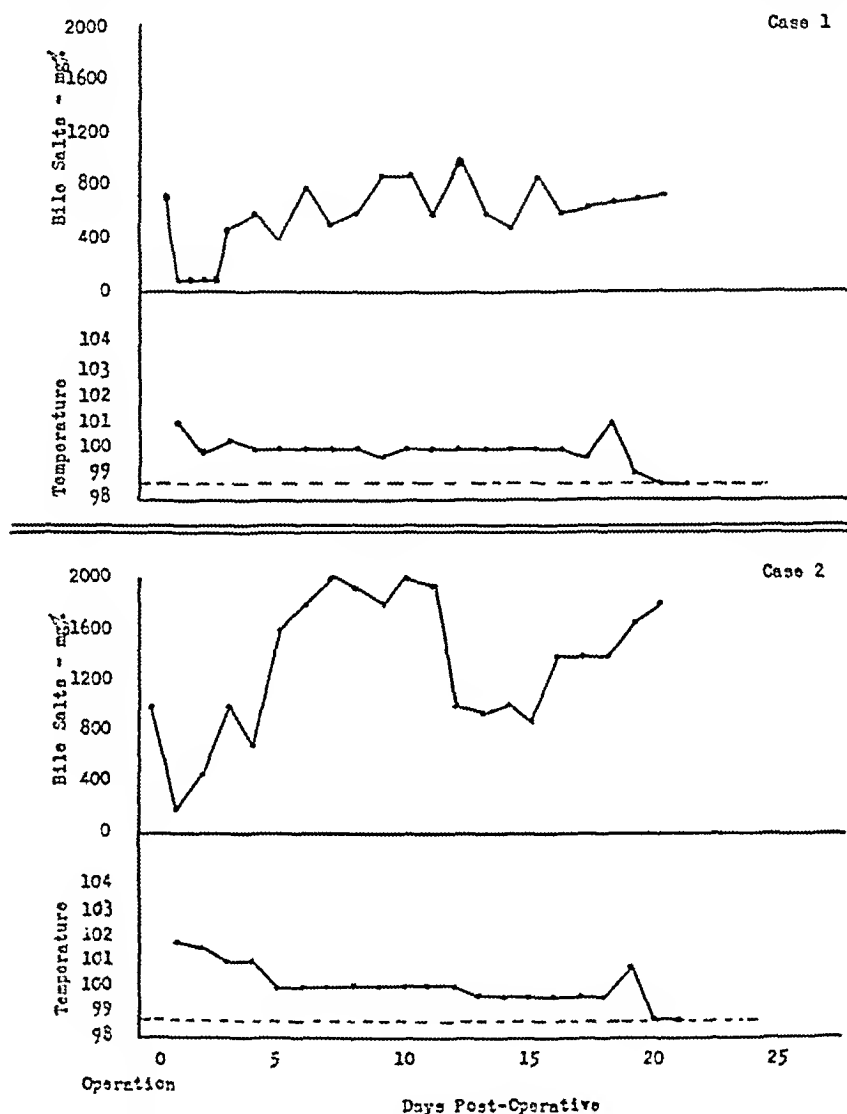


FIG. 1. The postoperative concentration of bile salts in two patients with normal livers.

therefore, are presenting two representative case reports from each group with a discussion of the probable factors influencing the results noted.

#### THE CONCENTRATION OF BILE SALTS IN BILE FROM PATIENTS WITHOUT EVIDENT HEPATIC DAMAGE

The eleven individuals in this group cannot be considered normal, as all were operated on for disease within the biliary tract. It may therefore be assumed that

examination, by physical examination and by appearance at operation, the liver apparently was normal. The concentration of bile salts in the bile from such livers is illustrated in Figure 1.

**CASE 1.** A white woman was admitted with a history of repeated biliary colic over a period of two years. Four days before admission she developed jaundice, the icteric index rising to 50 units. There was a direct Van den Bergh in the serum and a low concentration of bile salts in the duodenal drainage bile.

Upon operation the gall-bladder was chronically inflamed and contained many "mixed" gallstones. The common bile duct was dilated and contained a solitary stone much like the stones found in the gall-bladder. The cystic duct was dilated. A cholecystectomy and a choledochostomy with T-tube drainage were done. The liver was normal in appearance.

The concentration of the bile salts in the fistula bile is charted in Figure 1. The temperature curve, showing an uneventful recovery, is also included.

**CASE II.** A white woman had a history of intermittent epigastric pain over a period of twenty years. There was no jaundice except for a mild short attack fifteen years before. On admission the blood cholesterol was 125 mg. per cent, the cholesterol esters 145 mg. per cent, the icteric index 9.0 units, and the duodenal drainage showed concentrated bile with calcium crystals and a colon bacillus on culture. The gall-bladder was not visualized roentgenographically.

Upon operation, the liver was normal in appearance, the gall-bladder chronically inflamed, containing many stones. The common duct was dilated but thin walled. It contained calcium bilirubinate stones quite different in appearance and structure from their fellows in the gall-bladder. On culture, the common duct bile contained colon bacilli though the duct was not microscopically inflamed. The concentration of bile salts and the temperature curve are shown in Figure 1.

**Discussion.** These two patients with apparently normal livers present the findings general to the cases we have listed as normal. In Case I, only a low normal concentration of bile salts was attained during the twenty days of the study, while in Case II concentrated bile was secured soon after operation. In all our normal cases there was an initial postoperative depression in the concentration of bile salts which usually regained a level of 800 mg. per cent within a few days, although in several cases this was delayed up to the tenth day. Very frequently a secondary decrease in concentration occurred after six to fifteen days of drainage. This may have been due to a deficiency of bile salts resulting from the prolonged drainage through the T-tube

as well as to a reduction in carbohydrate intake following the discontinuance of parenteral administration of glucose solution. Due to these and other variables, it is impossible to assess the degree of hepatic damage on the basis of the postoperative concentration of bile salts alone.

The cholesterol content of the fistula bile did not parallel the concentration of bile salts in the two cases shown or in any of the patients we studied. It was generally of a normal concentration in our normal cases, unless there was an associated cholangitis in which instance cholesterol sometimes disappeared from the drainage bile.

#### THE CONCENTRATION OF BILE SALTS FROM PATIENTS WITH MILD HEPATIC DAMAGE

These patients, with evidence of slight but definite hepatic disease, showed a relatively rapid postoperative return of bile salts to normal levels. The extremely variable concentrations shown in Figure 2 are due to factors to be discussed later. When the 14 cases in this group are treated as a unit, the results are consistent within the clinical classification of the amount of liver disease seen. This, however, does not hold for individual cases. We are, therefore, presenting two case reports with variable concentrations of bile salts in the fistula bile.

**CASE III.** A 64 year old white woman was admitted with a history of epigastric pain of eighteen months' duration, associated with nausea, vomiting, and distention. Three weeks before admission, jaundice appeared. The icteric index was 15.0 units, the Van den Bergh reaction was direct. The gall-bladder was not visualized roentgenographically.

Upon operation, the gall-bladder was chronically inflamed and obliterated. The common bile duct was dilated, noncalculous, and thin walled. A chronic pancreatitis was considered the cause for the dilatation. The liver was slightly granular. A cholangiogram twelve days postoperatively showed a normally functioning common duct which emptied immediately. The concentration of bile salts in the fistula bile is given in Figure 2.

CASE IV. A 39 year old woman was admitted to the medical wards with typhoid fever. At the end of the third week she was

*Discussion.* The history and the chemical work-up in these cases did not indicate any liver damage. The macroscopic appear-

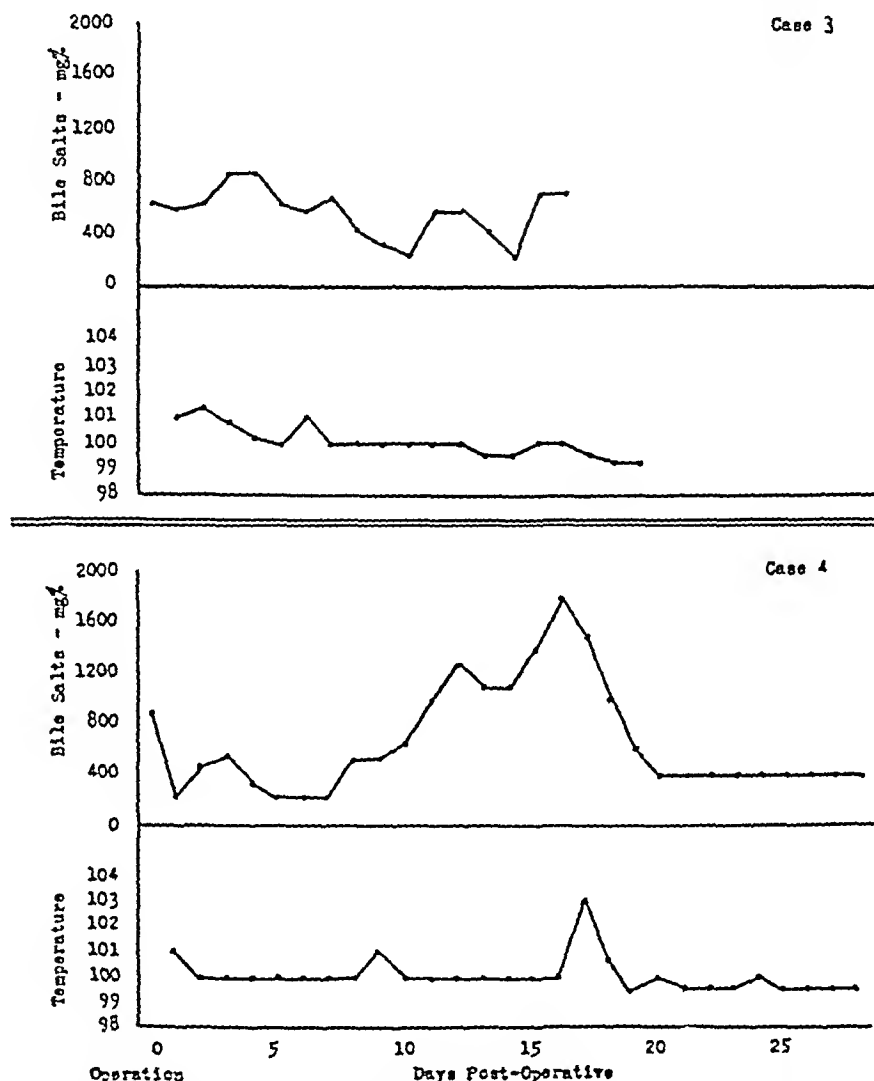


FIG. 2. The postoperative concentration of bile salts in two patients with mild or minimal hepatic damage.

suddenly seized with severe abdominal pain and mild jaundice appeared. After three days' observation, she was operated upon for acute cholecystitis.

The gall-bladder was found to be acutely inflamed, calculous and very edematous. The liver was enlarged and discolored. The common bile duct was dilated but contained no calculi. A cholecystostomy was performed. The post-operative bile salt concentration is given in Chart. iv. In this patient the concentrating ability was definitely interfered with by the febrile reaction until after the tenth day.

ance of the liver, however, and the evidence of severe cholecystic disease in both instances were evidence of some hepatic impairment. In both instances the liver had the ability to secrete bile salts in moderate concentration but the response was variable in both cases. This irregularity in Case III and the delay in the return of function in Case IV apparently were not dependent on the intrinsic disease of the liver but rather on the concomitant factors of a low grade cholangitis in the one, and a

general systemic infection with associated acute involvement of the gall-bladder in the other.

#### THE CONCENTRATION OF BILE SALTS IN PATIENTS WITH MODERATE HEPATIC DAMAGE

Prolonged partial obstruction of the common bile duct predisposes to continuing "insult" to the liver with a variable degree of hepatic damage. Eighteen such cases are included in this series. In each instance the history and the preoperative chemical findings were substantiated by the operative finding of hepatic disease. The two cases (v and vi) are representative of the functional behavior of such livers and their response to medical therapy and the removal of the obstruction.

**CASE V.** A 61 year old female had a long history of epigastric pain radiating to the right and left upper quadrants. Eighteen months before this admission, she had had a cholecystectomy and a choledochostomy for chronic cholecystitis and choledocholithiasis. The symptoms, however, continued. Two weeks before admission she developed jaundice which was continuing in type. The blood cholesterol was 205 mg. per cent, the esters 60 mg. per cent, the icteric index 44 units, the Van den Bergh reaction direct, and the serum bilirubin 9.4 mg. per cent. Duodenal drainage showed a moderately concentrated bile containing calcium crystals and colon bacilli.

Upon operation, typical calcium bilirubinate stones were found in a dilated common duct, which was infected with colon bacilli. The liver was enlarged and granular. Chemical examination of the common duct bile showed 775 mg. per cent bile salts and a trace of cholesterol. The postoperative concentration of bile salts in this patient with liver disease and cholangitis is shown in Figure 3.

**CASE VI.** A 57 year old female was admitted with a history of epigastric pain of eighteen months' duration. During the preceding two months she had intermittent jaundice. Three years previous to admission she had had a cholecystectomy for biliary colic from which she had been relieved. The blood cholesterol was 230 mg. per cent, the cholesterol esters 55 mg. per cent, the icteric index 170 units and

the serum bilirubin 14.5 mg. per cent. On duodenal drainage the bile was dilute and contained calcium and calcium bilirubinate crystals in large amounts. A colon bacillus was found upon culture of the bile.

Upon operation, the common bile duct was markedly dilated and contained a very large calcium bilirubinate stone. The common duct bile was dilute. The liver was granular, discolored and presented evidence of a biliary cirrhosis. The postoperative chemical studies on the bile salts in the fistula bile are shown in Figure 3.

*Discussion.* These two patients undoubtedly had moderate to marked hepatic damage both by history and at operation. Both had secondary choledochostomies performed for recurrent common duct stones. In spite of the advanced disease, both secreted bile salts at all times even though in diminished concentration. The true degree of hepatic damage was best shown by the slow return to a moderate concentration of bile salts in the fistula bile. This at no time reached a concentration we consider as a low normal (800 mg. per cent). Case v showed a similar inability to secrete cholesterol apparently associated with the infection of the common duct by colon bacilli. This, however, was not true of Case vi which had even more severe hepatic damage as well as an active cholangitis. Both of these patients have been followed biweekly for nearly two years and show a continuing cholangitis, but they have recovered their hepatic function to a marked degree as is evidenced by a moderately concentrated bile on duodenal drainage.

#### THE CONCENTRATION OF BILE SALTS IN PATIENTS WITH SEVERE HEPATIC DAMAGE (COMPLETE OBSTRUCTION)

The degree and duration of an extra-hepatic biliary obstruction is not necessarily an index to the degree of hepatic damage. Four subjects in our series had complete obstruction produced by stricture of the common bile duct. The response of



the liver to the removal of the obstruction was variable, but in no instance did the liver fail to secrete bile salts shortly after relief from the obstruction.

duodenal drainage, though the tube was proven to be in the duodenum.

Upon operation, there was a complete stenosis of the common bile duct. A bulbous

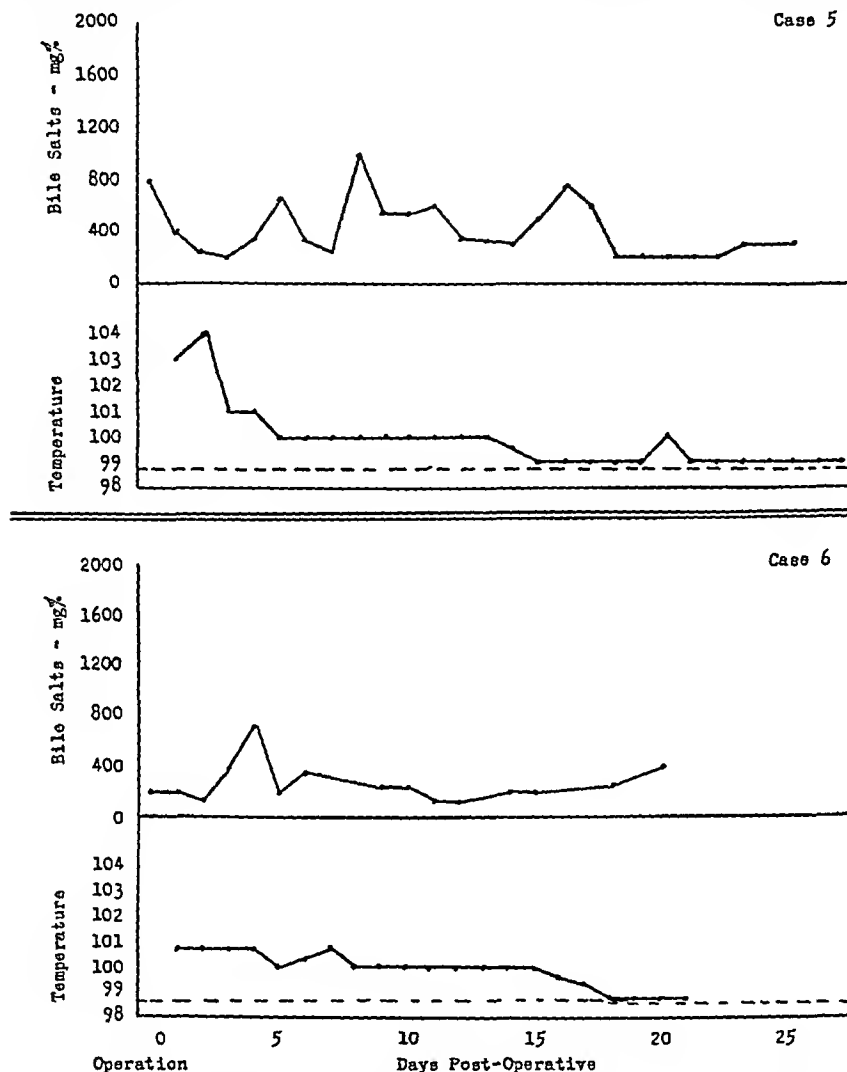


FIG. 3. The postoperative concentration of bile salts in two patients with moderate to marked hepatic damage.

**CASE VII.** A 42 year old woman had a cholecystectomy six months before admission to this hospital. Six days following her initial operation, she was operated on again for intra-abdominal hemorrhage. Two months after this operation jaundice appeared. It was progressive and painless though associated with nausea and vomiting. Upon admission she was deeply jaundiced. The blood cholesterol was 240 mg. per cent, the cholesterol esters 70 mg. per cent, the icteric index 186 units, the Van den Bergh direct, and the serum bilirubin 19 mg. per cent. No bile could be secured on

protrusion at the hilus of the liver was identified as the dilated end of the junction of the right and left hepatic ducts. The hepatic ducts were anastomosed to the duodenum over two T-tubes. The operative bile, aspirated from the bulbous protrusion described, was white and contained no bile salts and only a trace of cholesterol. The response of this liver, which had been completely obstructed for a period of several months, is shown in Figure 4.

**CASE VIII.** A 58 year old woman was admitted with a history of severe epigastric pain, nausea, and vomiting of three years' duration.

These symptoms followed closely upon a cholecystectomy for chronic cholecystitis and cholelithiasis. Jaundice was severe at times

of a probe after the removal of the stones and a stricture was thought to exist at or near the ampulla. A T-tube was inserted into the com-

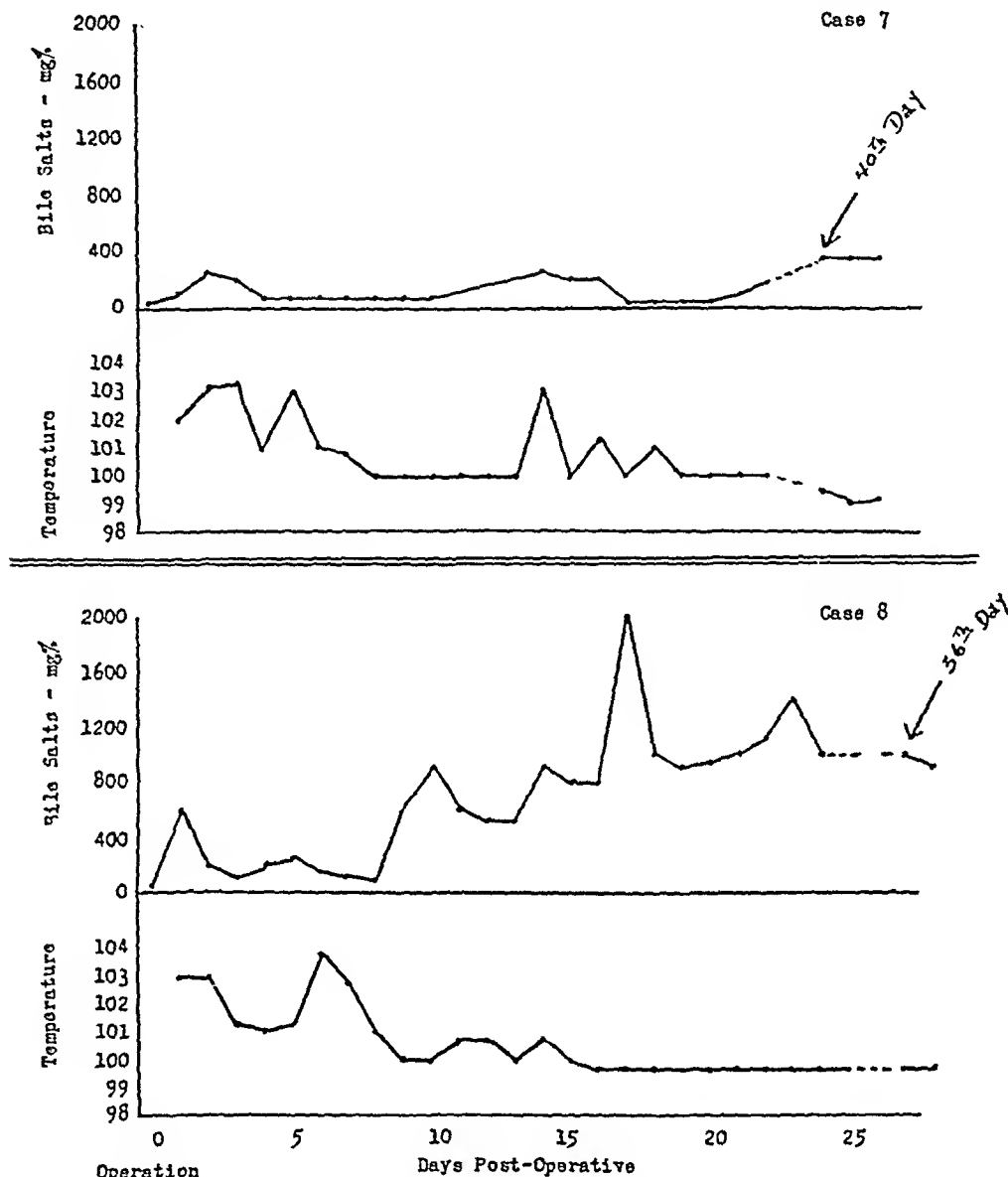


FIG. 4. The postoperative concentration of bile salts in two patients who had complete obstruction of the common bile duct with "white" bile in the hepatic ducts at the time of operation.

but apparently variable in intensity though always present. On admission the blood cholesterol was 210 mg. per cent, the icteric index 43 units, the Van den Bergh direct and the serum bilirubin only 4.3 mg. per cent. The degree of icterus increased during the patient's preoperative stay.

Upon operation, the common bile duct was found markedly dilated, containing white bile. Several pure pigment stones were found in the common duct, one of which completely obstructed the common bile duct at the ampulla. The duodenum could not be entered by means

mon bile duct for temporary relief, for the liver showed advanced biliary cirrhosis. The patient, discharged on the thirty-eighth postoperative day, was still draining profusely through the common duct fistula. Unfortunately, she could not be brought back for follow-up. Figure 4 shows the response of this severely damaged liver to relief from the obstruction.

**Discussion.** The two cases cited were undoubted complete obstructions of the extrahepatic biliary tree. In spite of this, both responded promptly to relief from the

obstruction and bile salts appeared in the drainage bile during the first twenty-four hours. This finding is contrary to that reported by Ravdin, Johnston, Riegel and Wright who, in eighteen cases of complete obstruction of the common duct, found an absence of bile salts for seven or more days in each patient. We believe that complete absence of bile salts in the bile is of severe prognostic import and is found only in complete hepatic failure.

#### INFECTION (CHOLANGITIS)

Infection of the common bile duct is one of the factors other than hepatic damage that adversely affect the concentration of bile salts in fistula bile. Although it may be argued that it is a direct cause of hepatic damage, we shall consider infection as a separate entity in the present discussion. Gray, Butsch and McGowan have shown that a febrile reaction, regardless of cause, will depress the concentration of the bile salts in the bile and will retard the return to a normal concentration after the initial postoperative depression.

The two following cases represent an apparent impairment of hepatic function in patients whose livers were only mildly diseased.

**CASE IX.** A 57 year old male had a history of mild attacks of intermittent jaundice for thirty months, with weight loss, nausea, distention, and occasional epigastric distress. Blood cholesterol was 305 mg. per cent, cholesterol esters 120 mg. per cent, icteric index 11.5 units. The Van den Bergh reaction was direct but the serum bilirubin was normal. Duodenal drainage showed a moderately concentrated bile containing calcium bilirubinate and cholesterol crystals. Cultures showed the presence of colon bacilli. The gall-bladder was not visualized roentgenologically.

Upon operation, the gall-bladder was large and edematous but without calculi. The common duct was dilated to 3 cm. in diameter and contained several calcium bilirubinate stones. On digital examination of the interior of the common duct a radial papillomatosis of the ampullary end of the duct was recognized. A cholecystogastrostomy and a T-tube drainage

of the common bile duct were done. Repeated cultures of the drainage bile showed the continuing presence of colon bacilli and streptococci. The postoperative concentration of bile salts, the bile culture reports and the febrile course are shown in Figure 5.

**CASE X.** A 48 year old woman was admitted with a history of right upper quadrant pain for the past fifteen years. There was no jaundice until three days previous to admission when it appeared, associated with dull upper abdominal pain. The jaundice increased until the patient was operated upon seven days later. The blood cholesterol was 256 mg. per cent, the icteric index 32.6 units, the Van den Bergh direct and the serum bilirubin 4.5 mg. per cent.

Upon operation, the gall-bladder was acutely inflamed and contained many calculi. The common duct was edematous, dilated but free from stones. The liver was not remarkable. The operative bile from the common duct was light in color and contained numerous pus cells and crystals. On culture, colon bacilli were identified. Cholecystectomy and choledochostomy were performed. The convalescence was stormy. On several occasions the drainage bile showed cultures of colon bacilli. Figure 5 gives the results of daily determinations of the concentration of bile salts and the febrile course.

**Discussion.** In neither of these cases was there any macroscopic evidence of hepatic disease. The patients were treated assiduously by means of parenteral dextrose, free drainage of the common duct and supportive measures. The concentration of bile salts from the fistulas of these patients at no time returned to the minimal normal concentration. In Case ix the determinations were continued for fifty days. Throughout this time the patient, though otherwise in good condition, ran a continuing fever with colon bacilli and streptococci cultured from the bile. The acute febrile reaction noted between the thirtieth and thirty-sixth postoperative days was induced by clamping the T-tube and so retarding drainage. The concentration of bile salts immediately fell. These findings were also present, though in a lesser degree in Case x. It would appear that a cholangitis and/or a febrile reaction will depress the concentration of bile salts

secreted by the liver. These cases show the difficulty of determining the functional state of the liver solely on the basis of the concentration of bile salts in its secretion.

nearly all the cases of this series has been ascribed by Gray, Butsch and McGowan to the effect of anesthesia. No difference was seen by us in the effects of various

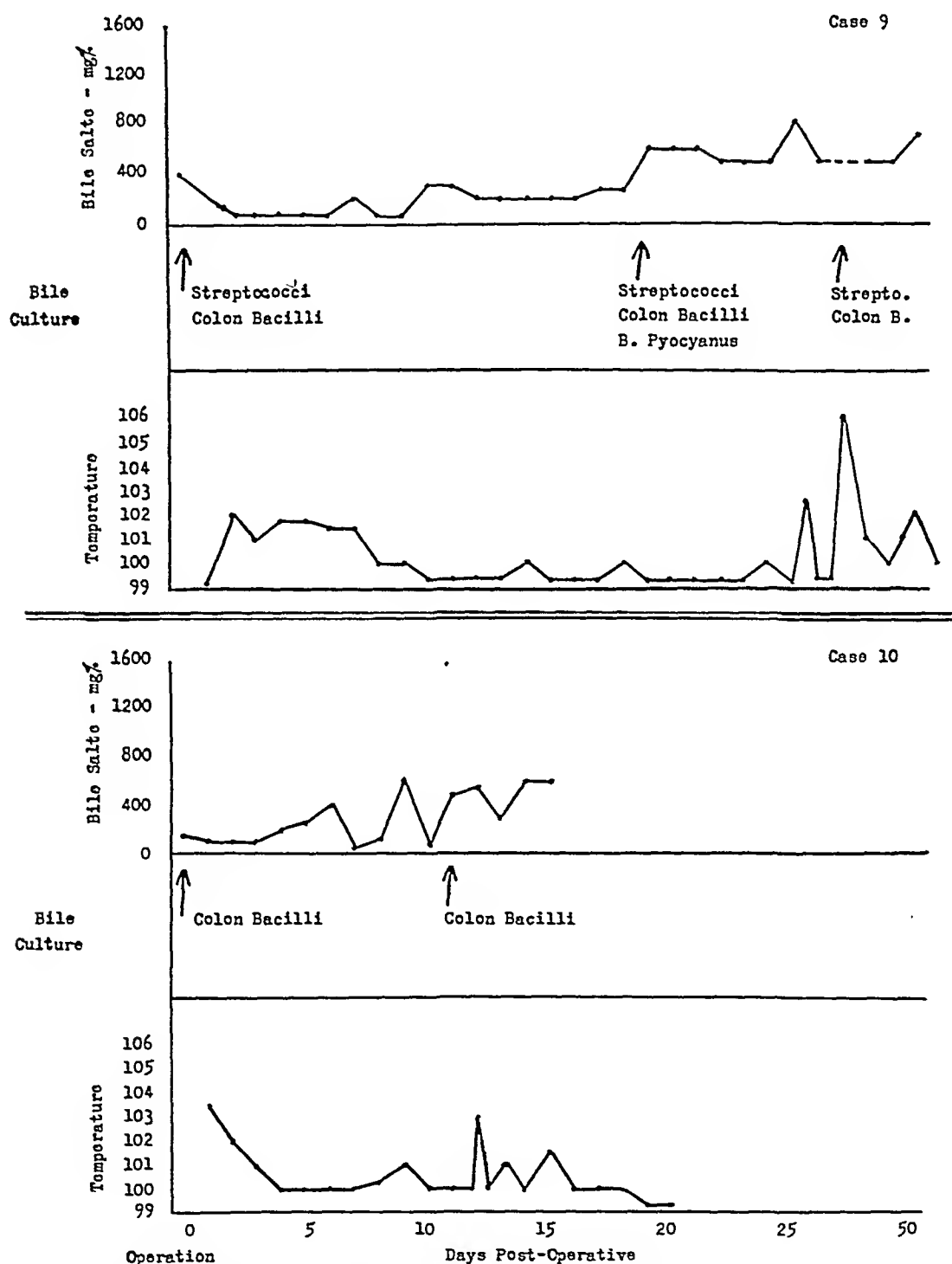


FIG. 5. The postoperative concentration of bile salts in two patients with an active purulent cholangitis.

#### ANESTHESIA AND OPERATIVE TRAUMA

The initial postoperative depression in the concentration of bile salts noted in

anesthetic agents on the degree of the initial depression. Severe operative trauma and prolonged operating time, as well as

the anesthesia, cause a continuing post-operative depression in the concentration of bile salts from apparently normal livers.

Case xii (Fig. 6), however, had a more severe cholecystitis with pericholecystic adhesions and several stones in the common

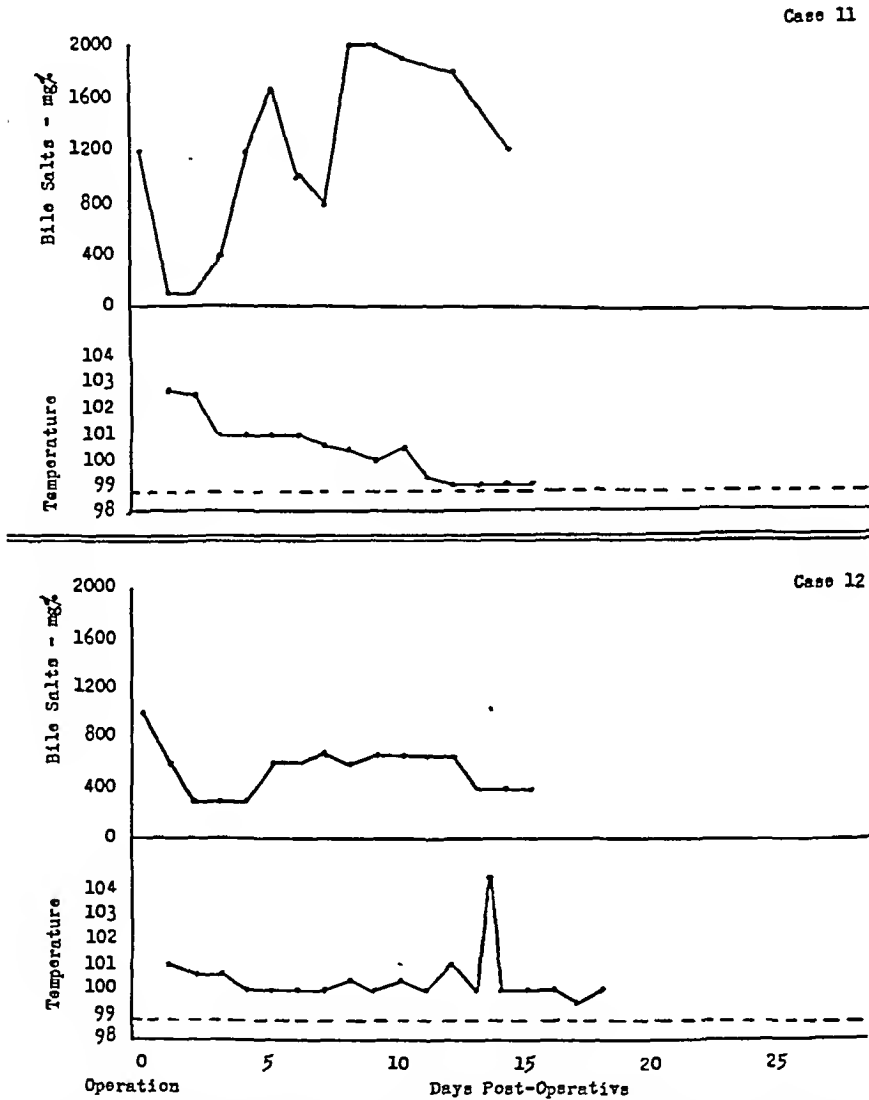


FIG. 6. The postoperative concentration of bile salts in two patients, one of whom (Case xi) had minimal operative trauma and the other (Case xii) severe operative trauma.

Case xi (Fig. 6) illustrates the immediate postoperative depression that is generally seen in fistula cases. The bile salt concentration had returned to normal by the fourth postoperative day. This patient had a chronic cholecystitis with a moderately dilated common duct so that cholecystectomy and choledochostomy were easily accomplished in forty-five minutes.

In spite of this pathology, the liver appeared normal and was without evidence of obstruction. Cholecystectomy and choledochostomy required nearly two hours and were completed only after considerable trauma to the liver. It is probable that in the majority of cases the duration of the anesthesia and the operative trauma contribute as much to the postoperative

hepatic insufficiency and retard the rate of return to a normal hepatic function as does the choice of anesthetic.

#### GLUCOSE ADMINISTRATION

Many clinicians have noted the clinical improvement in jaundiced patients upon the parenteral administration of dextrose solution. A high carbohydrate diet, in patients with less severe jaundice, apparently improves the function of the liver. Eliason and Erb,<sup>21</sup> and Ravdin, Rhoades, Frazier and Ulin<sup>22</sup> have shown that such therapy has in recent years reduced the mortality of surgery on jaundiced patients. Gray and his co-workers observed no immediate effect of dextrose administration upon the concentration of bile salts in fistula cases. Our experience contradicts their findings, in that in eight of our cases in whom a secondary diminution of concentration was seen late in the drainage period, administration of dextrose in increased amounts has brought forth an increase in the concentration of bile within two hours. It does not necessarily follow that the dextrose was responsible for this response, but in Cases XIII and XIV such a relationship appears to have been established.

**CASE XIII.** A 74 year old woman was admitted with a short history of right upper quadrant pain. A mild jaundice developed three weeks before admission and persisted. She had had a cholecystectomy thirty years before for calculous cholecystitis. The icteric index was 15 units, the Van den Bergh direct and the serum bilirubin below 2 mg. per cent.

Upon operation the common bile duct was markedly dilated and contained two calcium bilirubinate stones. The liver was granular in appearance but otherwise not remarkable. A choledochostomy was performed. The patient had a stormy postoperative convalescence.

She was given some parenteral dextrose for the first three days. This was discontinued and the patient placed on a soft diet. The bile salts diminished to only 50 mg. per cent by the sixth day, at which time intravenous dextrose was given with an immediate increase in concentration of bile salts. This treatment was

continued up to the eleventh postoperative day. Upon discontinuing this therapy, the concentration of bile salts again diminished. It finally rose on the fourteenth day, probably the response to recovery of function by the liver. (Fig. 7.)

**CASE XIVA.** A 60 year old woman had a history of sharp epigastric pain of six months' duration. She had no jaundice at any time. At operation an obliterated calculous cholecystitis was found. The liver appeared normal. There were two stones in the common duct, different from their fellows in the gall-bladder. Cholecystectomy and choledochostomy were performed. Convalescence was prolonged but uneventful. Figure 7 shows the concentration of bile salts in this patient during the immediate postoperative period. At no time was she given parenteral dextrose.

**CASE XIVB.** Eighteen months later she returned with similar symptoms as well as jaundice of two weeks' duration. At this time her blood cholesterol was 205 mg. per cent, cholesterol esters 60 mg. per cent, icteric index 44 units, Van den Bergh direct and serum bilirubin 9.4 mg. per cent. Duodenal drainage showed a moderately concentrated bile containing calcium and calcium bilirubinate crystals and a pure culture of colon bacilli. She was prepared for operation by means of a high carbohydrate diet and daily infusions of dextrose solution. The concentration of bile salts over a period of three weeks is given in Figure 7. On the twenty-second postoperative day, after the severe secondary diminution in concentration we have previously described, a detailed hourly study was made of the concentration of bile salts following the use of intravenous dextrose. The result of this study is shown in Figure 8.

**Discussion.** In these two cases we have attempted to reduce the variables as much as possible in order to show the response of the liver in bile salt secretion to the administration of dextrose. In Case XIII, the patient, with moderate liver disease, had only a slight concentration of bile salts in the bile. On the administration of dextrose, this rose, only to decrease when this form of therapy was discontinued.

In Case XIV we have a better example of the response of a liver to the administration of dextrose. At her first operation this

patient received only routine care. The concentration of bile salts in her fistula bile was minimal throughout the twenty-four

the icterus was greater than on the first admission. She was prepared by the administration of adequate amounts of car-

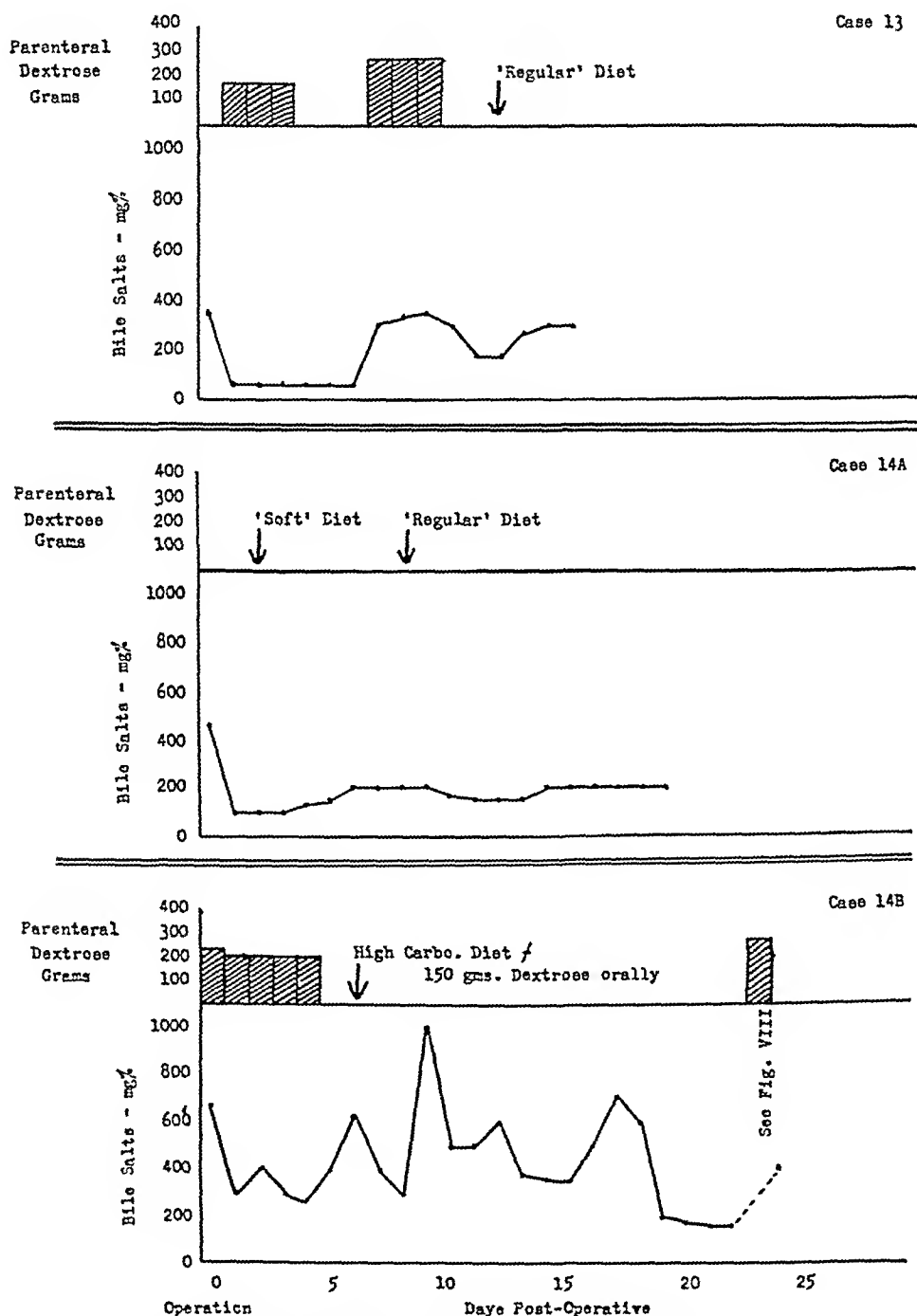


FIG. 7. The postoperative concentration of bile salts in cases showing the influence of dextrose administration on the degree of concentration.

days of study. When she returned for a second operation the degree of hepatic impairment measured by the intensity of

bohydrates. This preoperative preparation was reflected in the higher concentration of bile salts found in the bile at opera-

tion and secreted by the liver immediately after operation. When, on the nineteenth postoperative day the concentration of bile

put. That this was no accidental finding is shown in Figure 9 on which the hourly determinations have been graphed. The

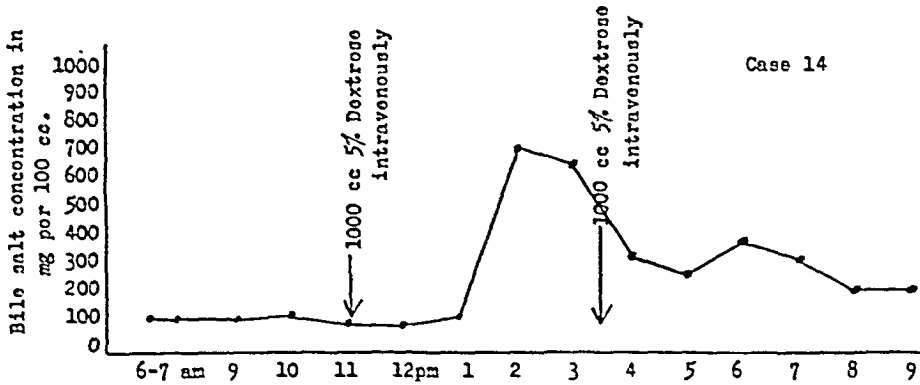


FIG. 8. The hourly determination of the concentration of bile salts following dextrose therapy in a patient 22 days postoperative.

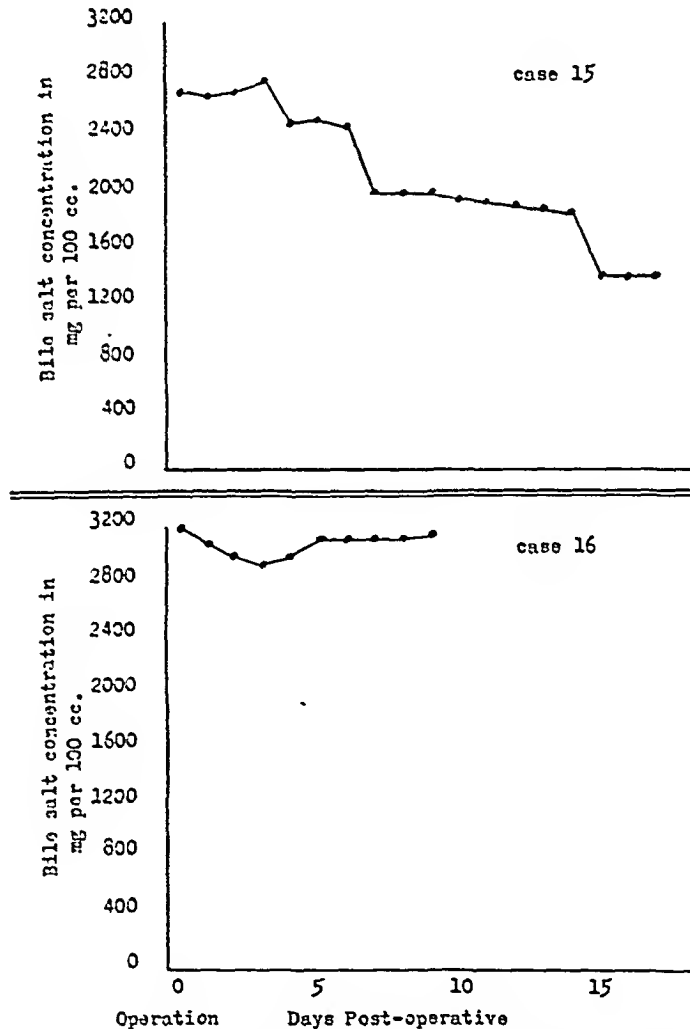


FIG. 9. The postoperative secretion of concentrated bile suggesting the concentrating action of the common bile duct in two patients with normal livers but with markedly dilated common bile ducts.

salts diminished, dextrose was given, with an immediate increase in the bile salt out-

experiment has eliminated to a large extent the many variables seen in these cases and



leaves little doubt that in this case the dextrose did improve the functional activity of the liver. Whipple reported that the bile salt content from fistula bile was reduced when dextrose was administered and thought this due to a conservation of the bile salts by the liver. The cases cited, as well as the results in fistula patients who were adequately prepared with dextrose preoperatively, indicate that the bile salt secreting function of the liver is improved by the administration of dextrose.

#### BILE AND BILE SALT ADMINISTRATION

Considerable study has been devoted to the value of the administration of bile salts to patients with biliary fistulae. Kohlstaedt and Helmer<sup>11</sup> are certain that the oral administration of bile salts increases the concentration of bile salts in fistula bile. They found that the ingestion of natural bile caused the greatest increase in concentration. Doubilet and Colp<sup>22</sup> in experiments on both humans and dogs, came to a similar conclusion. They believed that the salts of cholic acid were the most efficacious. The most satisfactory tests for bile salts in bile give only the cholic acid content and therefore the increase in total bile salt content cannot be accurately determined. Clara,<sup>24</sup> and Cantarow and Stewart,<sup>25</sup> found that dehydrocholic acid and its salts (decolin) act as a protective mechanism to the liver in obstructive disease of the extra-hepatic biliary tract.

Mixed bile salts were administered to the cases in this series, usually beginning on the second or third postoperative day. In eight cases the fistula bile was re-administered to the patient by proctoelysis. No effect on the concentration of bile salts in the fistula bile could be noted in these patients though the general physical condition improved, the ability to take food increased, and flatulence and nausea decreased. Such improvement in the physical state of patients has also been reported by Ravdin, Riegel, Johnston and Morrison.<sup>26</sup> We could come to no conclusion concerning the efficacy of the administration of bile salts

in increasing the concentration of bile salts in fistula bile.

#### CONCENTRATING ABILITY OF THE COMMON BILE DUCT

The ability of the common bile duct to concentrate the hepatic bile under certain abnormal conditions has been established by Schmidt and Ivy,<sup>27</sup> Sweet,<sup>28</sup> Boyd,<sup>29</sup> Sutton,<sup>30</sup> and others. The bile from a T-tube may be concentrated by the common bile duct and so not be true hepatic bile. This increase in the concentration of the bile will depend upon the length of time the bile is in the common duct before entering the T-tube and is directly dependent on the total volume of bile secreted and the size of the common duct. The concentrating ability of a dilated common duct must therefore be considered in interpreting the finding of concentrated bile from a T-tube fistula. Two case reports and chemical studies that illustrate this factor are presented.

CASE XV. A male, age 50 years, was admitted with a short history of continuous epigastric distress for three months. One month after the onset, he noted jaundice which continued up to the time of operation. The blood cholesterol was 290 mg. per cent, the cholesterol esters 120 mg. per cent, the icteric index 70 units, the Van den Bergh direct, and the serum bilirubin 2.4 mg. per cent. Concentrated bile was secured on duodenal drainage. The duodenal bile contained calcium bilirubinate and cholesterol crystals. The gall-bladder could not be visualized roentgenologically.

At operation, the gall-bladder was found dilated, inflamed and filled with stones. The cystic duct was completely occluded. The liver was enlarged but of normal color and appearance. The common bile duct was dilated to a diameter of 3.5 cm. It contained no stones and a probe entered the duodenum with ease. A cholecystectomy and choledochostomy were done. The bile aspirated from the common duct at operation was markedly concentrated. Figure 9 shows the postoperative drainage findings in this patient.

CASE XVI. A 67 year old male had had a cholecystectomy, ten years previous. He was

admitted with a history of epigastric pain of one year's duration. The pain radiated to both right and left upper quadrants. Jaundice appeared four days before admission. The blood cholesterol was 187 mg. per cent, the icteric index 100 units, the Van den Bergh direct and the serum bilirubin normal. Duodenal drainage showed a concentrated bile containing clumped calcium bilirubinate crystals and colon bacilli.

Upon operation, the common bile duct was dilated. It contained calcium bilirubinate stones. The bile was concentrated (3,070 mg. per cent bile salts) and cultures were positive for colon bacilli. The liver was enlarged, discolored and granular. After removal of the stones, the duct was found to be patent. Figure 9 gives the bile salt concentration of the fistula bile for the first eight days. The T-tube was inadvertently removed at this time, but in spite of this the biliary sinus healed in three days and the patient made an uneventful recovery.

**Discussion.** It is difficult to correlate the findings in these two patients with those seen in other patients with apparently normal livers. The high concentration of bile salts in the operative bile and the continuation of such high concentrations postoperatively is presumptive evidence that the common bile ducts of these patients had the ability to concentrate the bile. It may be argued that the secretion of the liver was so concentrated but analysis of the normal cases fails to reveal hepatic bile with a concentration over 1600 mg. per cent unless the common bile duct was markedly dilated. Further evidence of the ability of the common bile duct to concentrate bile salts is given in the fact that on clamping the T-tube the concentration increased. It is, therefore, probable that in the interpretation of any study of the concentration of bile salts from the liver, the ability of the common bile duct to concentrate the bile must be considered.

#### SUMMARY

The postoperative changes in the concentration of bile salts in the bile have been studied in a series of surgical patients

following drainage of the common bile duct through a T-tube. When the patient has had no evidence of hepatic disease or the latter is minimal, there is a temporary reduction in the concentration of bile salts in the bile, followed after two to three days by a progressive return to normal levels. This drop is interpreted as due to such factors as the type and duration of anesthesia, the local and constitutional effects of operative trauma, the degree of preoperative biliary obstruction with hydro-hepatosis, and the like.

The rapidity of the postoperative return toward a normal concentration of the bile salts in the bile and the maximal concentration attained during the period of observation in general are inversely proportional to the degree of hepatic damage. Evidence is presented that such factors as systemic infection, cholangitis, depletion of bile salts from prolonged drainage, and an inadequate supply of carbohydrate will reduce the concentration of bile salts in the bile, presumably as a result of functional as contrasted to structural changes.

The multiplicity of factors which apparently affect the functional ability of the liver and so the concentration of bile salts in the bile correspondingly increase the difficulty in determining the factors responsible for the changes in any individual case.

Evidence was obtained suggesting that in some instances the common bile duct may concentrate the bile passing through it in the same manner as is done in a normal gall-bladder.

The continued failure of the liver to secrete bile salts in the bile is evidence of severe functional disturbance and so of serious prognostic import.

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# WHEN TO OPERATE AND WHY, AND WHAT OPERATION TO DO IN ACUTE CHOLECYSTITIS\*

RUSSELL S. FOWLER, M.D., F.A.C.S.

Surgical Director, Wyckoff Heights Hospital; Consulting Surgeon, Methodist-Episcopal, Beth Moses and Bayridge Hospitals

BROOKLYN, NEW YORK

THIS presentation is founded on records of over 1500 personally operated cases covering many years and on many more cases in which operation was not advised. Conclusions have been arrived at from a study of not only the immediate mortality but also the morbidity results.

Acute cholecystitis is but one type of gall-bladder disease and forms a very small proportion of all gall-bladder cases. Gall-bladder disease itself is a chronic, slowly progressive inflammation with a large incidence in relation to population, beginning in young adult life and gradually increasing in severity with markedly variable clinical manifestations, the latter so variable as many times to pass as negligible factors. The disease is subject in a large proportion of cases to long periods of latency of clinical manifestations and in a small proportion of cases to sudden exacerbations of acute inflammation. In the course of the disease the function of the liver is affected to a variable degree. Nearby organs are affected through lymphatic supply (pancreatitis, localized hepatitis); through contiguity (adhesions, perforation); and through mechanical affects (pancreatic duct). Distant organs and mentality are affected through liver disturbance (jaundice, impaired liver function) and through the gall-bladder, acting as a focal infecting agent (kidney lesions, heart lesions, joint lesions). The disease is not only widespread, but has limitless potentialities.

*Incidence.* Our experience leads us to believe that gall-bladder disease is even more wide spread than was formerly supposed, for the following reasons: It is only

in the last two decades that the knowledge of gall-bladder pathology has been sufficiently well known to permit us to consider autopsy findings as minimum rather than maximum figures. Moreover, even now the gall-bladder which I described in 1916 as cholecystitis catarrhalis subacuta, the first stage in gall-bladder disease, is perhaps not recognized through its gross pathologic appearance by any except the expert.

*The Proportion of the Disease Which Is Surgical.* Considering gall-bladder disease as defined, only a very small percentage of cases require surgical intervention. It is estimated that of every 100 cases eighty either become quiescent or present such minor disturbances as not to interfere very much with the patient's well-being and therefore do not require surgical intervention. Of the remaining twenty there are perhaps fifteen in which operation is distinctly indicated and five in which it is a question of judgment as to whether or not operation should be performed. Of the cases which in all probability will require surgery at some time or other, the proportion in which immediate surgery is necessary is quite small.

Medical treatment is indicated in all acute inflammations of the gall-bladder showing a tendency to subside, with the exception of acute cholecystitis with gangrene, perforation, empyema and cholangitis. Medical treatment is also indicated in chronic cholecystitis tending toward latency and in hydrops of the gall-bladder (unless the tumor produces pressure symptoms or worries the patient) and in cholecystitis cicatrans not giving pain. Medical treatment is indicated in the acute cases

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because they are usually temporary, and in both acute and chronic because they are not disabling, do not give the patient much discomfort and do not interfere to any great extent with his enjoyment of life and his ability to earn his living.

Per contra, surgical treatment is indicated in acute cholecystitis which does not subside quickly, cholangitis both acute and chronic, gangrene of the gall-bladder, perforation of the gall bladder, beginning carcinoma of the gall-bladder, in all cases of chronic cholecystitis (of which there are many forms) in which health is affected over a period of time through recurring attacks of pain and where comfortable digestion and the pursuit of a livelihood are definitely impaired.

We differentiate between two classes of surgical cases: those in which operation must be done at once in order to save life; and those in which we have time to consider whether operation is advisable. In the first group the physician and surgeon must throw the weight of their experience in the balance to influence the patient's decision; they must insist upon immediate operation. In the second class there is time—the case may be studied and discussed with the patient and a mutual decision is arrived at in accordance with the degree of interference with the patient's comfort and earning power.

In the first class are the cases of acute cholecystitis not rapidly subsiding, the cases of seropurulent chronic cholangitis, acute cholangitis, gangrene of the gall-bladder. In the second class there are cases of chronic cholecystitis in which the patient's comfort and occupation are being materially affected. In the second group it is really up to the patient to give the final decision. We can, however, lay before such a patient his probable chances for cure or at least for the decided amelioration of his symptoms by operation and also the mortality of such an operation in skilled hands.

The desirability of tiding over the acute cases is indicated by 545 operations for

acute conditions with a resultant mortality of 10.3 per cent compared with 661 operations for chronic conditions with a mortality of 2.3 per cent. Both series include common duct involvement.

Very few cases of acute cholecystitis are immediately brought to the surgeon, so to speak of operation as immediate is not quite correct. These patients are seen two or three days, sometimes a week, after the initial symptoms. Patients seen very early, i.e., within twelve hours of the beginning of an acute attack, are generally treated like cases of acute appendicitis; immediate operation is done, sometimes because the case is improperly diagnosed as acute appendicitis and the real lesion is discovered only at operation. Such patients usually do very well both as to mortality and morbidity. The cases seen at a somewhat later date and in which the diagnosis is properly made, which may be called *delayed operated cases* (necessarily delayed because they were not brought to the surgeon in the very inception of the attack), may or may not be better operated upon immediately. It is my custom to delay operation for a few hours until it can be determined whether the disease is progressive. If so, so-called immediate operation is done; if not, the patients are carried over to a period of quiescence. Otherwise, we might find the pathology so acute and extensive as to cause undue mortality in what should be the operation of election, namely cholecystectomy (278 acute cases with a mortality of 6.5 per cent). If the case can be tided over to a period of quiescence, then this procedure may be done much more safely (589 operations in chronic cases with a mortality of 1.9 per cent).

If immediate operation is necessary, the type of operation will depend upon the pathology present and the acuteness of the inflammation. Cholecystectomy should be done if this is possible without undue risk (6.5 per cent mortality as compared in 278 cholecystectomies with 235 cholecystostomies in acute cases with a mortality

of 12.8 per cent; the cholecystostomies presented very acute and extensive pathology). In deciding between these operations, I am guided by the amount of inflammation at the base of the liver as shown by inflammatory thickening and adenitis surrounding the cystic duct and the site of emergence of the hepatic ducts from the liver. When this inflammation is intense and massive I prefer cholecystostomy as being the safer. One must also consider the presence or absence of jaundice. If it is absent, either method may be indicated; if jaundice is present, an exploration of the common duct is in order, either by touch or by incision and exploration. It is to be recalled that very frequently the jaundice which we find at times associated with acute cholecystitis is due to pressure on the common duct or hepatic ducts by the adenitis at the base of the liver and not to intraduct obstruction. I rarely use drainage in cholecystostomies in acute cases, aside from tube drainage of the gall-bladder, unless common duct drainage is also done. In acute cholecystitis where the gall-bladder has been removed, I usually use a cigarette drain to the foramen of Winslow. A comparison of 543 cholecystectomies with drainage and 240 without drainage showed that both mortality and morbidity were better in drained cases.

Morbidity in these procedures, excluding choledochostomies, cholecystenterostomies, cholecystgastrostomies and choledochoplasties, has been studied in the postoperative records of 979 cases for three to twenty-five years. Those patients relieved of all symptoms are called well, those who

have an occasional slight indigestion or suffer at times from over-eating are classed as having mild symptoms. Of 165 cholecystostomies, 58.1 per cent were well and 14.5 had mild occasional disturbances of digestion; that is, 72.7 per cent were practically well. Of 814 cholecystectomies, 86.6 per cent were well and 9.7 per cent showed mild symptoms; that is, 96.3 per cent were practically well. These good results would have been much better had the patients been operated on before the liver was damaged so extensively as to require treatment even after the infecting focus was removed, and before the inflammation had resulted in adhesions, stricture of ducts, perforation, gangrene, peritonitis, cholangitis, liver insufficiency, hepatitis, liver abscess; distant infections from the local focus such as myocarditis, renal insufficiency, pulmonary infections, joint complications; involvement of neighboring organs through extension of the inflammation such as pancreatitis, perforation into the stomach, duodenum or colon, adenitis causing pressure on the common duct either beneath the liver or at or near the ampulla of Vater; carcinoma of the gall-bladder following long-continued chronic irritation, to say nothing of the discomfort and disability from the at first localized disease.

#### SUMMARY

It has been the purpose of this paper to show what acute cases should be operated on, what is the best time for operation, what type of operation is safest, and what operation gives the best final result.



# OVARIAN NEOPLASMS: THEIR PATHOLOGIC AND SURGICAL SIGNIFICANCE\*

VIRGIL S. COUNSELLER, M.D.

Division of Surgery, The Mayo Clinic

ROCHESTER, MINNESOTA

OVARIAN neoplasms belong to the group of most common lesions encountered in the practice of medicine and surgery. Some are more important than others, yet not one, even if it is benign, can exist for very long without the loss of ovarian function and finally complete destruction of the organ. The results of treatment of both the benign and the malignant types are often disappointing. In addition, the pathologic characteristics of these neoplasms, it seems to me, have not been sufficiently stressed. A clear conception of the type of tissue being dealt with is the fundamental basis for the application of correct surgical principles in treatment.

The ovary is one of the most complex organs in the human body in that it not only is an organ of reproduction but also produces hormones of internal secretion which profoundly regulate many physiologic processes of the female. Many of the functions of the ovary are known but I am certain that others are not known and are not even suspected. These probably will not be discovered until more intense study is made in the physiologic chemistry of the various cells in the ovary. In this connection it is of interest that only recently a close relation between calcium metabolism in muscle and ovarian function was reported. That factors other than reproduction are related to the ovary is shown by the fact that cancer of the breast is rare among castrated women. Cancer of the body of the uterus has likewise not been encountered among patients whose ovaries have been removed before the onset of the natural menopause. This does not hold true for patients who have been given radium or

Roentgen therapy sufficient to produce a menopause, but in whom the ovary has not been removed or completely destroyed. At present, no one knows how much irradiation is required to produce the same effect as bilateral oöphorectomy. These observations are cited merely to stimulate interest in the complexity of the functions of the ovary and to emphasize that lesions of the ovary, whether benign or malignant, should receive more careful consideration.

Surgical treatment of ovarian lesions should be undertaken with meticulous care and only after due consideration. The indiscriminate removal of the ovary for simple cystic conditions or for so-called ovarian pain whether proved or not, should be condemned.

The consistency of ovarian tissue in different individuals has a great range of normal variation as to size, irregularities of the surface, thickness of the cortex and the number of retained follicular cysts. Also, the appearance of the organ varies tremendously according to the phase of the menstrual cycle. For example, there may be a blood clot of moderate size adjacent or adherent to a corpus luteum; yet this may be entirely normal. Occasionally both ovaries may be slightly elongated and irregular as a result of retained follicles, and yet be normal for the particular patient, who has, very likely, sought treatment for periodic attacks of pain in the right and left lower abdominal quadrants. In most instances of this type attacks are due to rupture of a retention cyst or occasionally to slight oozing of blood from the wall of the cyst. Not infrequently such patients are submitted to an appendectomy and if

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this does not give evidence of acute disease, the ovary often is removed as the cause of the pain.

For some uncertain reason the ovary may never function properly, or if once it has functioned normally, its function may become arrested. Yet to all gross appearances it is normal. Occasionally this derangement is secondary to faulty function of some other organ closely related to the generative organs; for example, the thyroid gland. This condition during the third decade of life is a very real problem to the patient and to the physician. Young women in this group are subjected to many varied types of therapy; some respond well to proper management whereas some do not.

Radium therapy has been prescribed with the idea of producing temporary abeyance of ovarian function, thereby controlling uterine hemorrhage. This procedure brings about in a young woman a temporary artificial menopause which seems to me absolutely contraindicated. If the bleeding cannot be controlled by any type of substitution therapy in an otherwise normal individual, I am of the opinion that abdominal hysterectomy with preservation of the ovaries is justified and is the logical surgical treatment. It is true that the ovaries sometimes become cystic and require surgical removal, but not all of them will require it by any means. The percentage of survival of the ovaries after hysterectomy is determined for the most part by the extent of the interference with their blood supply. The ovarian branches of the uterine arteries usually are destroyed, but the main ovarian artery and vein are not disturbed. However, if these vessels in the ovarian pedicle are left under considerable tension the vessels will gradually become thrombosed and the ovary as a result will become cystic or atrophic.

It is important to distinguish between menstrual disturbances that arise from abnormal function of the ovary and those attending ovarian neoplasms. The histologic picture of the endometrium in both instances may be identical and in cases of

functional bleeding alone there is no objective evidence of lesions of the ovary. Neoplasms usually disturb normal ovarian function but not in every instance and not always to the same extent. To understand the ovarian disturbance in the endometrium it is necessary to be familiar with the physiologic and pathologic variations in the endometrium.<sup>2</sup>

Briefly it is sufficient to say that the endometrium is the most active tissue in the human body and that there is no so-called resting stage. In normal conditions the endometrium completely changes itself every twenty-eight days. The first fourteen days are designated as the proliferative phase, changes being brought about through the action of the follicle. The last fourteen days are designated the differentiative stage, controlled by the corpus luteum. Whenever failure of formation of the corpus luteum supervenes or if there is an excessive follicular effect, the endometrium becomes cystic. This has not been sufficiently stressed; it deserves attention since it denotes ovarian failure from some cause. A cystic endometrium in the past has been alluded to as hyperplastic, although it is not hyperplastic at all, but on the contrary, is evidence of degeneration.

One other point of extreme importance in this connection is that activity of the endometrium may be arrested at any point in the menstrual cycle; therefore, it may be designated pathologically as the persistent proliferative or persistent differentiative phase of the menstrual cycle, resulting in periodic menstrual bleeding or periodic amenorrhea.

A correlation of these findings in the endometrium with those of benign ovarian neoplasms, such as cystadenoma and adenomyoma, is often advantageous in planning surgical treatment. The cystadenoma is an outstanding example of a benign ovarian neoplasm. It arises in the substance of the ovary in contradistinction to the simple follicular cyst, and so when, as frequently happens, it reaches considerable size, the ovary usually is destroyed. Second, these neoplasms may be unilateral but unfortu-



nately a high percentage are bilateral, if not at the time of operation then later in life. If the endometrium reveals beginning ovarian failure with menstrual irregularities associated with a benign cystadenoma of one ovary, there are most likely small multiloculated cysts within the substance of the remaining ovary and the prognosis for correction of the disturbances of menstruation by removal of the one cystadenoma is not good. On the other hand, if the endometrium does not show degenerative changes the prognosis should be excellent. A large ovarian tumor that completely fills the abdomen of a young woman is usually of this type. It is not malignant, in contradistinction to the papillary cystadenoma which is malignant.

I wish to place considerable emphasis on the word "papillary" in this connection. I feel that it is pathologically sound to regard and to treat as malignant any tumor which results in the formation of papillary epithelium. To do otherwise is to court disaster. Papillary epithelium behaves in characteristic fashion regardless of where it is situated. For example, if it appears in the urinary bladder it may or may not be quiescent but if it is disregarded, eventually it will kill the patient.

Endometriosis (adenomyoma) is another benign lesion of the ovary important because of its frequency, its appearance in early adult life, its effect on sterility, the physical disability and the disturbance of ovarian function attending it. This lesion is not confined to the ovary, but the activity of any associated adenomyomas is entirely dependent on the ovary. Roentgen rays or radium therapy sufficient to bring about arrest of ovarian function will render all lesions inactive unless the ovary partially regains its function after such treatment.

The disturbance of ovarian function in this type of disease is a factor which is in need of very careful study. It has been my belief for considerable time that endometriosis of itself does not affect, to any appreciable degree at least, the function of the ovary, since most patients who have this condition have associated lesions of the

uterus or ovary which could sufficiently explain the menstrual irregularities. In a recent series of 308 cases I discovered that in 65.6 per cent menorrhagia, metrorrhagia or both occurred; this was approximately the same as the number of associated pathologic lesions of the uterus and ovary. However, the endometrial lesion may be the chief factor of the menstrual disturbance or an incident in a sequence of events resulting from ovarian failure. Some evidence which would tend to clarify this point might be found in a study of the incidence and distribution of endometrial lesions in cases of so-called functional uterine bleeding.

With regard to the effect on ovarian function, I have recently been impressed with the high incidence of cystic changes in the endometrium, ranging from a mild to a severe degree, among patients who have been subjected to operation primarily for endometriosis. Furthermore, the extent of cystic change seems to bear a definite relation to the amount of endometrial disease and hemorrhagic cysts of the ovary.

There is considerable disagreement among students of this subject in regard to whether hemorrhagic cysts (chocolate cysts) of the ovary are the result of endometrial ovarian lesions. Certainly in many cases of large hemorrhagic cysts there is no pathologic evidence of endometriosis in the ovary or wall of the cyst but endometrial lesions usually are identifiable on the posterior surface of the broad ligament adjacent to the ovary, although certainly not in great amount. When endometriosis is the outstanding abnormal condition present, the hemorrhagic cysts are usually very small but often multiple. Some of the cysts contain blood of recent origin and in some it is tarry as a result of decomposition of long standing.

We have observed also that when endometriosis is the predominant abnormal condition present, dysmenorrhea is the principal symptom, but when chocolate cysts are predominant, menstrual disturbance is the chief symptom. Pain and menstrual disturbance together usually denote

rather extensive involvement by both types of lesions.

The treatment of these lesions seems to me to be primarily surgical unless the rectovaginal septum is involved extensively by endometrioma, in which case radium therapy sufficient to arrest ovarian function would involve considerably less risk. However, if the pelvis is filled with large chocolate cysts it is wiser to perform bilateral oöphorectomy and leave the lesion in the rectovaginal septum undisturbed. In the case of a young woman who suffers predominantly from these lesions, the best treatment is to excise the involved structures and preserve the menstrual or the reproductive function or both. Such procedures are indicated only for patients whose lesions are not extensive or are confined only to one adnexal region because the incidence of recurring symptoms in cases of more extensive involvement is quite high. Sterility, of course, is a prominent complaint and is often the symptom which induces the patient to seek medical advice. There is associated with this disease an absolute sterility in about 32 per cent of cases, but to correct it surgically is not always possible. In 56.2 per cent of a group of patients who had been treated by conservative surgical measures pregnancy occurred, but 16.8 per cent of these pregnancies resulted in miscarriages. Hope is eternal in some women with regard to reproduction and if they can live under the impression that they can reproduce they have much more peace of mind.

If the evidence of ovarian failure is strong, as exemplified by menstrual irregularities and cystic endometrium, I feel that the patient will be better cared for by a subtotal hysterectomy and by excision of the ovarian lesions, without complete ablation of ovarian function. It has been my observation that the activity of small lesions which may remain in the pelvis is considerably reduced if the patient does not menstruate, although the ovarian tissue remains.

Radical treatment is required for extensive lesions of this type which excessively

involve the ovaries of patients who are in the latter part of the fourth decade of life. Also, considerable subacute pelvic distress due either to bacterial invasion or to the chemical action of blood pigment is more safely eliminated in this manner.

The significance of malignant lesions of the ovary is such that the question of preservation of ovarian function must be disregarded except in some unilateral carcinomatous cysts of a low grade of malignancy. It is unusual to find a malignant cyst in a woman under 35, but it does occur sufficiently often to keep one constantly looking for it. The malignant cysts which occur in the ovary are carcinomatous cystadenomas, papillary, nonpapillary or mixed. From the standpoint of pathology these cysts should not be such a serious matter, because the majority grow very slowly and often remain confined to the ovary for months. Unfortunately a great number develop after the menopause and the only associated symptom is enlargement of the abdomen. If they occur during the menopausal period, the menstrual irregularity is regarded too frequently as a normal process. Later when the cysts reach huge proportions the cyst wall becomes thinned, especially at the sites of greatest pressure, and finally becomes perforated. The malignant process then rapidly spreads and the condition approaches the inoperable stage.

Complete surgical removal of all pelvic organs is the procedure of choice for patients 40 years of age or older, even if the cyst is unilateral. However, 50 per cent are bilateral at the time of operation. If the cyst has become perforated and there are secondary implants these may be held in check by Roentgen therapy.

True carcinomas of the ovary are of two types, the papillary adenocarcinoma and the solid adenocarcinoma. In this group of cases symptoms frequently are absent during the early or favorable operative period. Some of these growths can be discovered, however, by routine pelvic examinations, and often the patient is amazed to learn that there is something wrong with

her pelvic organs. Papillary adenocarcinomas originate as a rule from the surface of the ovary and, unfortunately, are of a high grade of malignancy. Since they extend from the surface of the ovary, they become attached early to adjacent structures and shortly assume such proportions that they become inoperable. Fluid in the abdomen is the rule and extension to other structures occurs in a few months. It is known that the prognosis is generally poor for cancers of this type, although many of the secondary growths become quiescent, as is the case in malignant cysts, if the parent growth is removed and the procedure is followed by the use of radium and Roentgen therapy. In my experience, the longest duration of life in such a case after this method of treatment was twenty years. It is important to note also that there is a high incidence of bilateral involvement, so that it is advisable to remove all the pelvic generative organs even if the growth is confined to only one ovary.

Solid carcinomas of the ovary represent a much smaller group than papillary adenocarcinomas, and they also vary in their rate of growth. Their presence is usually not suspected, and consequently there is a high incidence of pelvic attachment and extension to distant lymph nodes. Fluid in the abdomen is a frequent finding, and an undesirable one in relation to prognosis. The seriousness of this group of cancers was revealed in a recent study which showed that of the patients who had solid carcinoma, grade 3 or 4, more than 75 per cent succumbed within a few months due to recurrences.

The method of treating ovarian cancer is early surgical removal followed by radium and Roentgen therapy. In some cases of carcinoma, grade 1, confined to the ovary, irradiation is omitted. In many cases the lesions are definitely not amenable to surgical treatment but are treated, if the patient's condition will permit, by intensive radium and Roentgen therapy. Some time ago, I<sup>2</sup> investigated a recent series of 143 patients at the clinic. These patients had cancer of the ovary and were

treated with surgical procedures alone; 65.4 per cent of them were living five or more years after treatment. One hundred and eighteen patients received intensive irradiation in addition to surgical treatment and of this number 50.5 per cent were living five or more years later. Thirty-six patients had extensive lesions and were suitable for irradiation only; 16.7 per cent of them lived five years or more after such treatment.

#### UNUSUAL NEOPLASMS

Another small group of infrequent ovarian neoplasms must be considered in this connection. The first of these is the arrhenoblastoma, or masculinizing tumor of the ovary. The clinical syndrome which follows the onset of this tumor is a change toward a male type of habitus and a development of the secondary sexual characteristics of the male. The main physical features of the Cushing syndrome are absent. These growths are recognized easily both from the surgical and pathologic standpoints. If a patient who has previously had normal menstruation, experiences the slow development of amenorrhea plus the distribution of hair similar to that of males, enlargement of the clitoris and changes of the voice to the masculine type, the possibility that an arrhenoblastoma is present is indicated. Pathologically the tumor closely resembles the seminiferous tubules of the testis. For this reason it was first called "adenoma tubulare testiculare." It is of interest that this tumor varies in its differentiation from normal testicular tissue to a type that is hardly recognized as such. These cells secrete a hormone which influences secondary sexual characteristics in a masculine direction. Furthermore, the tumors that have the least resemblance pathologically to testis show the greatest masculinizing effect. It follows, therefore, that when these tumors are highly differentiated the masculine effect is greatly reduced and often unnoticed clinically.

This neoplasm frequently is classed as malignant but very rarely has metastasis been noted. If present, metastatic lesions

can be destroyed or rendered inactive by Roentgen therapy as the cells are very sensitive to Roentgen rays. The lesion is always unilateral and, since it extends but rarely beyond its initial site of origin, cure can be obtained by local excision. This is of especial importance because these tumors are seen during the menstrual life of the patient.

Another very interesting tumor is the granulosa cell tumor or feminizing tumor. This hardly can be said to be a rare tumor as about 400 have been reported. Sixty per cent of these tumors occur after the menopause and 30 per cent between puberty and the menopause; 5 to 10 per cent occur before the age of adolescence. The influence of these tumors differs for the three age groups just mentioned. For example, among young individuals the tumor produces precocious menstruation with early sexual and somatic development. In middle life the tumor produces either amenorrhea of itself or amenorrhea followed by profuse and continuous menses. However, after the menopause, this neoplasm gives rise to a periodic pseudomenstrual type of bleeding in 90 per cent of cases.

The syndromes produced at the various ages are explained by the effects of the large quantity of estrin elaborated by these tumors. This hormone can be identified in both the blood and urine of patients who have granulosa-cell neoplasm and in almost unbelievable amounts in extracts of the tumor tissue. Its effect on the uterus is exactly what one would expect from excessive activity of estrin—hyperplasia of the myometrium and a thick, boggy, proliferative type of endometrium, usually containing cysts. Why the effect of estrin among young people is different from its effect on patients of more advanced ages is not clearly understood.

Pathologically, 90 per cent of these tumors are said to be malignant but of a very low grade; therefore they rarely extend beyond the local initial site of origin. About 90 per cent of the lesions are unilateral and they are usually classified as

solid tumors. Different cell types are recognized but are not of particular interest.

Since these tumors are usually unilateral and are of a low grade of malignancy, conservative surgical measures can be safely and logically followed. After the menopause, however, panhysterectomy is usually in order.

The next two tumors of special interest are the dysgerminoma and Brenner's tumor, neither of which produces a hormone. The dysgerminoma is a very interesting lesion because, although pathologically malignant, clinically it runs a very benign course. This tumor is said to correspond to the seminoma of the testis with the exception that the latter behaves as its degree of malignancy would indicate. The tumor usually occurs in girls and young women who are less than 20 years of age. It is frequently bilateral and is associated with hypoplasia of the genital organs.

It is said that this is the most common lesion observed in pseudohermaphrodites and in individuals who have poorly developed gonads. It may be best classified as occupying a "neutral" position between the masculinizing arrhenoblastoma and the granulosa cell feminizing tumor. Although this lesion appears to be of a high grade of malignancy, cure is obtained by removal of the affected adnexa. When both ovaries are involved (35 per cent) complete hysterectomy with removal of both adnexa is indicated.

Brenner's tumor is a solid, non-hormone-producing tumor of the ovary although it may be found in association with ovarian cysts. It is characterized by slow growth and is similar to ovarian fibromas in lacking specific symptomatology. It resembles somewhat a granulosa cell tumor and microscopically it resembles a metastatic epithelioma. Surgical removal effects complete cure.

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# HYSTEROSTOMATOMY: DUHRSSSEN'S INCISION\*

## A PRELIMINARY STUDY

ISADORE A. SIEGEL, M.D.

Assistant Professor of Obstetrics, University of Maryland Medical School

BALTIMORE, MARYLAND

**H**YSTEROSTOMATOMY or Dührssen's incision of the cervix has been employed to a greater extent in recent years in a growing group of obstetrical cases which have tried the patience and judgment of many obstetricians. These cases present urgent indications for immediate delivery; yet the cervix is incompletely dilated and offers the principal obstruction to delivery. In some of these cases cesarean section has become contraindicated because of the risk to the mother due to prolonged labor, ruptured membranes and potential infection.

In former years the indications for hysterostomatomy were limited usually to two: (1) in the elderly primipara, and (2) in eclampsia. Forceful manual dilatation of the cervix is no longer considered a good procedure since it results in the tearing of the cervix, hemorrhage, shock and high morbidity. Cutting of the cervix, on the other hand, produces a clean surgical incision and eliminates the danger of shock.

*Indications.* In general the indications for hysterostomatomy are well expressed by Dr. F. L. Adair, as quoted by Hunt and McGee:<sup>1</sup> "Dührssen's incisions are permissible only in those cases where prompt termination of labor is in the interest of either the fetus, the mother, or both. The cervix must be adequately effaced though it is improperly dilated, and conditions must be such that the subsequent operation for delivery would be properly performed if the cervix were already fully effaced and dilated. It is an operation for the specially trained practitioners, to be carried out only in a suitable environment such as a well-equipped maternity hospital."

As a rule the indications for this operation are multiple in many individual cases. The labors are generally unsatisfactory, with poor or ineffectual pains; the patient is in labor for many hours; the presentations are often other than the anterior occiput; the membranes have ruptured prematurely or have been ruptured for many hours; and maternal exhaustion or fetal distress is present although the cervix is incompletely dilated and immediate termination of labor is necessary. In many of the cases, despite frequent rest periods induced by sedation and the maintaining the mother's strength by intravenous fluids, labor progresses far too slowly and even comes to a standstill.

In our series of Dührssen's incisions performed at the University Hospital from 1935 to 1938, inclusive, we find that the indications may be classified as follows:

*Maternal Indications:* 1. Maternal exhaustion as a result of prolonged labor associated with primary or secondary uterine inertia and malpresentation of the head.

2. A true Bandl's contraction ring.

3. Pre-eclampsia with slow labor.

4. Labor coming to a standstill in an elderly primipara.

5. Previous cesarean section with thin uterine scar.

*Fetal Indications:* In any case where evidence of fetal distress is present, and where prolapsed cord is found.

*Contraindications:* It is generally agreed that placenta previa is an absolute contraindication for the operation since fatal uncontrollable hemorrhage may result

\* From the Department of Obstetrics, University of Maryland Medical School.

from extensions into the enormous uterine sinuses.

#### SUMMARY OF FINDINGS

*Age and Parity.* Seventy-eight cases of hysterostotomy were performed at the University Hospital from 1935 to 1938, inclusive. In this series, sixty-nine were

TABLE I  
INDICATIONS FOR HYSTEROSTOMATY

Fetal Indications	
Fetal distress.....	27
Prolapsed cord.....	3
Transverse presentation.....	1
Postmaturity.....	2

Maternal Indications	Com- bined	Alone
Exhaustion.....	28	1
Occiput posterior.....	23	6
Transverse arrest.....	16	0
Bandl's contraction ring.....	1	0
Uterine inertia.....	5	1
Elderly primipara.....	1	0
Pre-eclampsia.....	7	1
Chronic nephritis.....	3	0
Previous cesarean section.....	1	0
Disproportion.....	5	0
Face presentation.....	2	0
Brow presentation.....	1	2
Cervical dystocia.....	19	2
Breech.....	3	1
No progress.....	1	0
Eclampsia.....	1	0
Premature separation of placenta.....	1	0

essentially primigravidae; eight of this number gave a history of one previous abortion. The remaining nine patients were multigravidae. The ages of the primigravidae varied from 15 to 41 years with an average of 21.6 years; the ages of the multigravidae ranged from 16 to 38 years with an average age of 30.7 years.

*Labor and Presentation.* In fifty-one cases where prolonged labor was one of the indications for delivery the average duration was 41.8 hours. In sixty cases the presentations were other than occiput anterior; thirty were occiput posterior; twenty-one were transverse arrest; two were face; two brow; one transverse presentation; and four breeches.

*Indications.* In most instances the indications for the operation were multiple and included both the mother and baby. (Table I.)

*Methods of Delivery.* The methods of delivery (Table II) give some idea as to the types of cases. In sixty-nine cases (primigravidae) episiotomy was necessary.

TABLE II  
METHODS OF DELIVERY

Low forceps.....	20
Mid forceps.....	31
Mid axis traction.....	12
Seanzoni.....	3
Breech extraction.....	4
Internal version and extraction.....	5
Craniotomy.....	3

*Types of Incisions and Extensions.* The usual incisions in the cervix are generally made at 10, 2, and 6 o'clock but in this series we find that in fifty cases the incisions were made at 10 and 2; in seventeen cases, at 10, 2, 6; in four cases, only one incision; and in eight cases the number of incisions was not noted. It has been an interesting finding that in the majority of the cases the posterior lip of the cervix is fairly well thinned out while the anterior lip remains rather thick, so that only the 10 and 2 o'clock incisions seem to be necessary. In nine cases the incisions in the cervix extended and lacerations occurred in addition to the incisions. It is important to note that these lacerations and extensions were noted only in those cases where but two incisions into the cervix were made. This would indicate that it is definitely safer to make the three incisions in order to avoid extensions or lacerations.

*Morbidity.* It is to be expected that in cases in which there are generally multiple indications for delivery, where the mother is exhausted by long labor, and where surgical interference becomes necessary, morbidity would be high. In this series the morbidity was 24.36 per cent.

*Fetal and Maternal Mortality.* Twenty-one babies died: fifteen were full term; two premature; and four were dead before delivery. Thus giving a gross fetal mortal-

ity of 21 per cent. The maternal mortality in this series was one, or 1.28 per cent.

*Weights of Babies.* Weights of infants are given in Table III, with indication of

TABLE III  
WEIGHTS OF BABIES

Gm.	
Less than 1500.....	1
1500-2500.....	6
2500*-3000.....	21
3000-4000.....	45
Over 4000.....	7
Total.....	80

\* Two sets of twins.

prematurity, maturity and postmaturity. There was a high incidence of large babies, 65 per cent being in the group from 3000 to over 4000 gm.

*Postpartum Hemorrhage.* Postpartum hemorrhage was increased in this series. No exact method of measuring the amount of blood loss was employed and only approximate estimations were made. Considering an estimated loss of 500 or more c.c. as a postpartum hemorrhage we find that this occurred in eleven cases, or 12.8 per cent.

*Healing of the Cervix.* We were very much interested in following these cases to learn the condition of the cervix at the six weeks postpartum examination and we were successful in securing data on this question in forty-eight patients. In forty-two of the patients the cervix was considered as well healed; in five as poorly healed; and in one case the cervix was adherent to the lateral walls of the vagina.

*Subsequent Pregnancies.* We also were interested in the possible effects of hysterostotomy on subsequent pregnancies as well as possible sterility. Since our series has been compiled in the last three years it is not expected that we would have sufficient data to answer these questions. However, we were able to find that in nine patients subsequent pregnancies have occurred. Seven of these have already been delivered of full term babies. Two labors ended spontaneously, three were assisted

with prophylactic low forceps, and two required cesarean section. Of the two cesarean sections, one was done for cephalopelvic disproportion as an elective procedure; and the other, after a trial labor with failure of the cervix to dilate, was done by low cervical section. In the five cases that were delivered per vaginam the shortest labor was two hours and forty minutes, the longest, eleven hours and thirty-eight minutes. The average duration of labor was six hours and eight minutes. In none of these five deliveries were incisions of the cervix necessary and in three cases inspection of the cervix following delivery showed lacerations. The weight of the babies delivered ranged between 3,515 and 4,649 gm.

#### CONCLUSIONS

1. Hysterostotomy (Dührssen's incision) is a valuable procedure in obstetrics.
2. The indications for this procedure are generally multiple, involving both mother and child.
3. The 10-2-6 o'clock incisions will prevent extensions and lacerations of the cervix.
4. The maternal morbidity and fetal mortality are necessarily increased.
5. The babies in these cases have a tendency to be large and overweight.
6. The cervix, in the great majority of cases, heals satisfactorily.
7. Postpartum hemorrhage is increased. This can be attributed to the general exhaustion of the patient and to the operative procedures necessary to complete delivery.
8. There is no tendency to sterility following operation.
9. Subsequent labors are not necessarily prolonged or interfered with.

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# SOME COMPLICATIONS OF A COLOSTOMY\*

HOMER I. SILVERS, M.D., F.A.C.S.

Surgical Director and Chief of the Department of Colonic and Proctologic Surgery

ATLANTIC CITY, NEW JERSEY

TO perform satisfactorily and be of least annoyance to the individual, a colostomy must be so constructed that it will discharge the fecal content of the bowel completely and with minimum danger of later complications. An improperly made artificial anus will not only be an annoyance to the patient, but will lend itself to accidents, that if foreseen, could in many instances have been avoided. Nearly all complications can be prevented if due attention is given to planning of the operation and time given to instruction as to the care of the colostomy in the daily cleansing. The position of the opening has much to do with the function of the bowel; whether the opening is in the portion of the gut containing semi-liquid feces or in a portion of the bowel with solid feces, will determine to a large extent how it will operate, and how it works will determine largely the comfort or discomfort of the patient.

One major complication that should be charged to a poorly constructed colostomy or an opening in a patient poorly instructed in its care, is the mental distress that may progress to the point where the individual shuns contact with society and becomes unfit to carry on his ordinary business. This need not be, for in a properly constructed and properly managed colostomy the man is able to carry on his work, laborious though it may be, with comfort and a minimum amount of care.

How soon a colostomy should be performed has been a point for argument over long years and while it is still a subject of discussion, the tendency now is to make a colostomy early. This holds good particularly for the inoperable cases of cancer of the rectum; to withhold a colostomy until

ulceration about the cancer has passed beyond the wall of the bowels is apt to make of the colostomy only one more complicating factor in the progress of the disease.

In the operable cancer of the rectum, the time of making a colostomy may to a certain extent be predicated upon the location of the growth and upon the time that resection is expected to be done. At the rectosigmoid a cancer can be expected to produce obstruction sooner than an involvement of the ampulla. Because of the capaciousness of the ampulla, obstruction may never occur, but at the rectosigmoid it may appear abruptly without much warning. A colostomy in the presence of obstruction, becomes a complicated procedure with a rapidly rising death rate.

In the inoperable carcinoma no subsidence of the disease can be expected, so that if any benefit is to be derived from the colostomy, it should be made early. It seems reasonable to consider the making of an artificial opening as soon as the diagnosis of inoperable carcinoma is made. Miles<sup>1</sup> sums this up very well when he states that as soon as carcinoma of the rectum is found to be inoperable, every day lost before resorting to colostomy is a day to the bad.

The type of colostomy will have something to do with the complications and accidents that follow. A simple loop colostomy, in which there is not a good spur, will give trouble because of the spilling over of feces into the distal limb, which becomes not only an annoyance to the patient, but a danger as well. Where the gut is divided, the ends widely separated and the abdominal wall closed between them, one may expect a colostomy to function to the

\* Read before the Proctologic Society of the Graduate Hospital, University of Pennsylvania, February 8, 1939.



highest point of efficiency, because all feces will discharge directly to the surface and only a small portion of the gut is exposed. This type of colostomy will require somewhat longer to construct and, if care is not exercised, may show a higher mortality.

The complications that arise from the location of the artificial opening on the abdomen are largely due to the inability of the patient to give proper attention to the opening. Improper care or lack of care invites the irregular action of the colon with its soiling, and the mental distress due to a sense of insecurity.

Peritonitis is an ever present menace to surgery of the colon, particularly in those cases of malignancy where extensive involvement has occurred. It is easy, with injudicious handling of a growth, to express infectious material through the damaged bowel wall. The incidence of peritonitis is remarkably higher in this type of surgery than in gastric or pelvic surgery, because of the anatomic conformation of the large bowel and its normal bacterial contents.<sup>2</sup>

Obstruction caused by the passing of the small intestine around the attachment of the sigmoid to the abdominal wall when care has not been used in closing the space between the colon and the lateral abdominal wall, is a complication that can be avoided by careful technique when making the colostomy. This technique should in some way completely obliterate the space between the sigmoid and lateral wall, at the same time allowing the knuckle of gut to come out through the abdominal opening with good spur formation, if a loop colostomy is made. If obstruction does occur it becomes a serious accident with a high mortality.

Various types of hernia may occur through the opening made in the abdominal wall to accommodate the protruding gut. The simpler type shows gradual dilatation of the abdominal opening with formation of globular distention under the skin, pushing the posterior wall of the protruding gut forward. This forward protrusion of the colostomy becomes a nuisance to the

patient; it is sometimes visible under the clothing; and it is always productive of increased moisture and because the surface is subject to increased traumatism, there may be bleeding. The wearing of bags with hard ring edges at the edges of receptacles will produce this type of hernia.

Pemberton<sup>3</sup> reports an unusual complication in a man with a colostomy who returned in one year because of hernia of the abdominal incision with prolapse of both limbs of the loop. This was repaired. In a little more than a year he returned because of another prolapse larger than he had ever noticed before. Attempts at reduction resulted in perforation of the prolapsed portion of the colon through which 2 feet of small intestine protruded.

Separation of the wound edges is not unusual in patients suffering from malignancy, and that being so, rupture of the wound in colostomy need not be an unexpected accident.

A man was admitted to the Atlantic City Hospital with a carcinoma of the rectum. A colostomy was done, with separation of the ends of the bowel and repair of the abdominal wall between. Two weeks after operation, during a severe fit of coughing, the wound opened and a loop of small intestine protruded between the ends of the colostomy. This accident is not an infrequent occurrence. In poorly nourished individuals the danger should be anticipated and steps taken to support the wound. When it does occur the protruding intestines are always soiled by extruded feces. However, because of increased tolerance due to autovaccination, peritonitis is less frequent than might be supposed.

An annoying complication is prolapse of the colon through the proximal opening which may under some circumstances result in protrusion of a large section of the gut. While several factors enter into the production of a prolapse through the proximal opening, the most common cause is to allow too much sag or freedom of movement in the proximal loop. This has often been presented as an argument against the formation of a colostomy.

It is a well known fact that scar tissue in the skin will contract more than in other organs, and therefore, if care is not taken in closing the skin around the gut, stenosis may occur. Some surgeons, to obviate this difficulty, remove an elliptical section as a preliminary to the abdominal incision. When stenosis does occur it frequently requires some form of plastic operation to secure a properly functioning outlet. The stenosis of colostomy opening will be seen more often around a single barreled colostomy than in a loop colostomy, since often a stab wound is made with tight fit around protruding gut.

We have had the unfortunate experience of extensive infection around the artificial opening and attributed the invasion to the fact that the bowel was sutured to the abdominal wall. We no longer anchor the bowel in any way that may require introduction of sutures into its walls.

In the care of a colostomy, we carefully instruct the patient in the necessity of properly irrigating the proximal colon at regular intervals. Caution should always be used in introducing a rectal tube into the colon; no force should be applied to the advancing tube and a large, stiff piece of rubber should not be used. If caution is not exercised the tube may puncture the bowel even after long familiarity with its use. In one of our patients, a man who for five years satisfactorily irrigated the proximal portion of the gut, this accident happened. One morning, due to lack of time, he applied undue force to the entering tube which penetrated the colon, and he then proceeded to inject at least a pint of water into his abdominal cavity.

Extension of the original disease into the colostomy is not an infrequent occurrence and can, to a certain extent, be avoided by being sure that the portion of the gut selected for the opening is free of disease, is a sufficient distance above the lesion, and that a similar invasion has not occurred about the point selected for section.

Bleeding from the protruding mucosa usually alarms the patient, but this ordinarily is caused by trauma of the

material covering the exposed mucous membrane and is usually rectified by attention to detail in the application of the dressing.

There is a very serious complication that may arise as the result of division of the mesentery in the formation of a single opening. The blood supply of the left colon is not so evenly distributed as that of other portions of the colon, so that if vascularity of the bowel is not certain, necrosis of the gut may occur with rapid onset of peritonitis.

Parotitis is frequently seen where the parotid gland lacks the stimulus of food taken by mouth. It may occur in various degrees of severity, often to the point of suppuration. It is well to have these patients chew gum or suck upon pieces of orange or lemon.

#### SUMMARY

To fulfill its purpose, a colostomy must function without distress or discomfort and with a minimum amount of attention.

There should be no mental hazard associated with an artificial intestinal opening, as otherwise a large proportion of the benefit is lost.

Many complications that arise as the result of the operative work or in the care of the colostomy, should be avoided by careful planning of the operative technique and a clear understanding of what is to be expected of the abdominal anus.

It is necessary to avoid or lessen the possibility of subsequent accidents if we expect to offer the colostomy as a substitute for a normal anus.

A colostomy should be so devised and constructed, and its after-care such that its presence will be only a minor handicap.

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# TUMORS ORIGINATING IN THE ISCHIOANAL FOSSAE

## REPORT OF CASES

RAYMOND J. JACKMAN, M.D.

Section on Proctology, The Mayo Clinic

ROCHESTER, MINNESOTA

**A**LTHOUGH tumors, exclusive of inflammatory processes, originating in the ischioanal fossae are uncommon, a particular problem in diagnosis and treatment arises when the condition is encountered.

In 1908, Chavelet was able to collect only eleven reports of neoplasms in this location, three of which were myomas, three fibromyomas, one a lipoma, one fibroma, one fibrolipoma, and two sarcomas. The only other report that I was able to find in the literature was one by Shedden in 1934, in which he reported three cases of sarcoma arising in the ischioanal region.

This study is based on a series of four cases seen recently at The Mayo Clinic.

As an aid in studying these reports and in understanding the path followed by the tumor as it enlarged, a review of the anatomy is indicated. In this study the term "ischioanal fossa" will be used instead of "ischioanal fossa" because the levator muscle is attached to the wall of the anal canal rather than to the wall of the rectum, and this fossa actually bears no immediate relation to the rectum but rather to the anal canal—hence the adjective "ischioanal."<sup>1</sup>

The ischioanal fossae are situated on either side of the anus and are normally filled with fibrofatty tissue. Each is pyramidal in shape, with the base pointing backward and the apex anteriorly and medially. Anteriorly they are separated from each other by the rectum and prostate (or vagina). Posteriorly they are in contact except at the anococcygeal raphé. Their lateral walls are relatively rigid and are formed by the ischial ramus, covered by the obturator internus muscle and aponeu-

rosis. Lying in a reduplication of this aponeurosis are the internal pudic vessels and nerves. The medial wall is relatively mobile and is made up from above downward of the levator ani, internal sphincter and external sphincter muscles. The levator ani muscle separates the fossae from the subperitoneal or pararectal space. The bases of the fossae are represented by the superficial fascia and skin. The apex is formed by the junction of the levator fascia and that of the obturator internus. The fossae measure approximately 5 cm. in the anteroposterior diameter, 2.5 cm. laterally, and 5 cm. to 7 cm. vertically. The fossae are lined with fascia covering the superficial surfaces of the obturator internus and levator ani muscles. This fascia is continuous with the fascia covering the gluteus maximus muscle, laterally, and Colles' fascia, anteriorly. The inferior hemorrhoidal vessels and nerves pass through the ischioanal fossa. Posteriorly, between the two fossae, is a fat-filled space by means of which the fossae can communicate by rupturing a very thin fascial layer.

It is therefore conceivable that new growths in this region could be either mesodermal or ectodermal in origin.

## REPORT OF CASES

**CASE 1.** A farmer, male, aged 49 years, registered at The Mayo Clinic because of a painless swelling in the region to the left of the anus, which he had noticed for about three months. Because of the progressive enlargement, it was causing him inconvenience on sitting or riding farm machinery. The results of proctoscopic examination were negative. Palpation disclosed that there was a circumscribed, movable tumor approximately the size of a baseball in the region of the left ischioanal fossa

which was not tender and to which the overlying skin was nonadherent. The mass was completely removed and it was found to be well encapsulated except at one point where it was attached by a pedicle in the region of the ischial ramus. Examination of the tumor revealed that it measured 7 cm. by 6 cm. by 5 cm. The microscopic report was "lipomyxoma containing small areas of bone." Recovery was uneventful and the wound healed by primary intention.

CASE II. A farmer, male, aged 50 years, came to The Mayo Clinic because of a painless tumor in the region of the left ischioanal fossa which, because of its size, caused some difficulty in sitting, and because of its location, caused difficulty in the local hygienic care of the anus. The tumor was found to be movable and well circumscribed. It was excised and proved to be about 10 cm. by 9 cm. by 8 cm. in size. The microscopic report was "lipoma." Recovery was uneventful.

CASE III. A man, aged 64 years had noticed a painless, progressively enlarged swelling to the right of the anus for one year and this was a source of concern because of his fear of cancer and the difficulty he encountered in the care of the anus after defecation. On digital examination of the rectum, the tumor could be palpated as an extrarectal mass on the right side. It seemed to be adherent to the wall of the rectum. It was excised and was found to be adherent to the levator ani muscle and wall of the rectum. The tumor was 10 cm. by 10 cm. by 10 cm. in size. The microscopic report was "fibroma, probably originating as a lipoma." Recovery was uneventful.

CASE IV. A farmer, aged 28 years, was brought to The Mayo Clinic because of swelling and tenderness to the left of the anus for ten days. On examination, a tender, bulging mass with reddened, overlying skin was discovered. Clinically, it was thought that this was an ischioanal abscess, and incision for drainage was attempted. However, it was found to contain hair and the usual necrotic debris of a dermoid. After the acute inflammatory process had subsided, the cyst was removed. The microscopic report was "squamous epithelial lined cyst."

Tumors of the ischioanal fossa, if non-malignant or noninflammatory, are usually painless and give rise to symptoms such as

discomfort in sitting and with bowel movement, only because of their size and location. They vary in size, and a combined rectal and vaginal examination may be of value in determining the size, degree of mobility and point of origin. Pressure on the contiguous structures may cause pain or alteration of such physiologic processes as defecation or urination. Unless secondarily infected, the overlying skin is freely movable.

These lesions must be differentiated from such pathologic processes as ischiorectal abscesses, pilonidal disease, chronic anal abscesses and perineal hernias. Ischioanal abscess is the most common lesion occurring in the region of the ischioanal fossa. It can be differentiated from benign tumors by the speed of development, fever, leucocytosis, tenderness, fluctuation and pain. It is more difficult to rule out an abscess of the lumbar region, such as occurs in Pott's disease, which may point near this region. However, the course of the disease and roentgenologic examination of the spine would be of help in diagnosis.

Pilonidal cyst disease, although usually located in the coccygeal region, may extend anteriorly to the midline of the anus or into the perineum. Perineal hernias are very rare, but can usually be differentiated by reducibility.

Chronic ischioanal abscesses or "incomplete" external fistulas usually are surrounded by a firm, fibrous or scarred wall and may be very difficult to differentiate from the rare tumors. Careful examination of the dentate margin to discover the primary source of the abscess in an anal crypt and palpation of the anus and perianal tissues between the index finger and thumb usually will disclose the site of origin.

#### SUMMARY

Tumors originating in the ischioanal fossa are rare. Such tumors present problems interesting in differential diagnosis and treatment.

The subjective symptoms caused by tumors of the ischioanal fossa, as shown by these cases, are not definitely peculiar to the lesion but in general include painless, progressive swelling which causes difficulty on sitting or defecation. The findings of asymmetry in the ischioanal region, overlying normal skin, and circumscribed movable tumor mass that is not tender are of value in differential diagnosis.

These tumors should always be excised and the tissue examined microscopically for the correct diagnosis.

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IN about 80 per cent of cases, carcinoma of the stomach occurs in a patient who has never been previously sick. Not infrequently he volunteers the information that it is the first time in his life that he has consulted a doctor.

FROM—"Surgery of the Alimentary Tract" by Devine (Williams & Wilkins Company).

# OXYGEN VENTILATION IN THE TREATMENT OF BLADDER TUBERCULOSIS

WESLEY JOHN KETZ, M.D.

Surgeon, Gray's Hospital

BATESVILLE, ARKANSAS

**T**UBERCULOSIS of the bladder is, essentially, a secondary lesion dependent upon a focus elsewhere in the genitourinary tract, usually the kidney or prostate. Primary tuberculosis of the bladder is such a rarity that its existence is open to question and, for practical purposes, one is justified in considering each case as a secondary lesion. Symptoms in fully 60 per cent of the cases promptly abate following extirpation of a unilateral tuberculous kidney. Local treatment, therefore, is withheld for a time after nephrectomy, but is indicated should improvement fail to occur after a period of six months. Subsidence of bladder symptoms is more likely and more prompt when the preoperative symptoms are of short duration. Even after unilateral nephrectomy a small percentage of patients will have persistent bladder symptoms resisting all forms of therapy, local and general, which are currently employed.

*Source of Infection.* Infection may reach the kidney by way of the blood stream, lymphatics, by extension through the ureter and by direct extension. The hematogenous route is most plausible. Invariably the primary renal focus is situated at the base of the pyramid in the region of the medullary portion of the renal cortex. Tuberculous pyelitis with its attendant symptoms develops when the process extends in all directions and breaks down spontaneously into the renal pelvis which is near the cortical surface.

*Pathology.* Tubercles, both miliary and conglomerate, occur in the mucosa, especially the trigonum, followed later by shallow, ragged ulcerations with nodular bases. Halle and Mortz divided the progress of vesical tuberculosis into three

stages: the first including tubercle formation and superficial ulceration preceded by an edema and reddening in the region of the ureteral orifice; the second being the stage of deep ulceration involving the muscular layer; and the third the destructive stage.

The tubercle bacillus is an aerobe and will not grow under strictly anaerobic conditions. Novy and Soule (1925) found that the optimum oxygen pressure for growths of the human type of organism was 40 to 50 per cent, while above and below this pressure growth was retarded. Carbon dioxide seemed to have little effect on growth; no inhibitions occurred till the concentration reached 60 per cent, and even in 90 per cent carbon dioxide fair growth occurred.

*Symptoms.* The symptom-complex of tuberculosis of the bladder is essentially that of renal tuberculosis. The renal lesion or primary focus is frequently suggested by the evidence of tuberculous cystitis. Frequency of urination, dysuria, and varying degrees of hematuria form the chief symptoms. The initial symptom of frequency varies in intensity and severity, and with exacerbations and remissions, tends to become chronic. Dysuria varies with the extent of the bladder ulcerations and may amount to extreme tenesmus. Hematuria is most variable in degree and occasionally may be massive. Systemic symptoms as vesperal fever, loss of weight, night sweats, pulmonic tuberculosis, etc., are often present.

The persistence of bladder symptoms following nephrectomy, according to Cabot, may be due to one of four reasons: (1) severe invasive cystitis with secondary contracture; (2) unsuspected dormant le-

sion in the remaining kidney; (3) pronounced vesical ulceration; (4) contracture of the vesical neck.

In a large percentage of cases even ulcerations do not prevent subsidence without supplementary treatment. Even contractures in themselves will improve through distention, either natural or artificial hydraulic.

**Diagnosis.** A diagnosis of tuberculous cystitis is frequently rather taxing. A history with especial reference to the triad of frequency, dysuria, and varying hematuria is of utmost importance. A thorough physical examination for possible primary focus of infection elsewhere in the body is necessary. Laboratory work is concerned chiefly with urinalysis and guinea-pig inoculation. A so-called "organism-free pus" is presumptive evidence of tuberculous cystitis. The presence of the tubercle bacillus in urine is an absolute assurance of tuberculous infection in the urinary tract. This is easily proved by the carbolfuchsin stain of the urinary sediment. Guinea-pig inoculation tests are positive. Cystoscopy will reveal tubercle formation and ulceration in the region of the ureteral orifice and trigonum.

A plain x-ray plate of the abdomen will often show tuberculous calcareous deposits irregular in shape and density. A cystogram may outline a bladder contracted more in one-half. A marked dilatation of the bladder sphincter and posterior urethra in the presence of a severe cystitis is highly suggestive.

**Treatment.** The local treatment of tuberculous cystitis is diverse. Thus, Herman recommends instillations of  $\frac{1}{2}$  ounce of gomenal in oil, 10 to 20 per cent, three times weekly, or 10 c.c. of a mixture of calomel 2, guaiacol 15, and sterile olive oil 100, once or twice weekly. Casper recommends the instillation of 20 to 30 c.c. of a 1:20,000 solution of bichloride of mercury, gradually increasing the strength to a 1:2000 solution. Hollander prescribes potassium iodide orally and a calomel emulsion instilled into the bladder to liberate

mercuric iodide. Silver nitrate 1:1000 is useful only in cases with a mixed infection, and is intensely irritating in the presence of open ulcers. Greenburg and Brodney advised methylene blue in 2 gr. capsules three times a day and an instillation of a 1 per cent c.p. solution into the bladder. Rousing suggested the use of phenol  $\frac{1}{2}$  to 6 per cent as a bladder instillation. Iodoform (5 to 10 per cent) or guaiacol 5 per cent in liquid petrolatum, picric acid 0.5 to 1.0 per cent, and mecurochrome 1 per cent, have also been used. Santol oil 5 to 10 minims and hyoscyamus 10 to 60 minims are useful internal remedies. Myll states that symptomatic improvement follows the intravenous injection of 5 c.c. of a 5 per cent solution of calcium chloride. The injections are made at five day intervals. Wizack employed lactic acid instillations in strengths of 20 per cent with satisfactory results. Caulk and Ewerhardt have used intravesical ultraviolet medication and air ventilation with beneficial results.

Various surgical procedures such as suprapubic cystostomy, ureterostomy, uretero-intestinal anastomosis and fulguration of the bladder mucosa have likewise been advocated from time to time.

In rebellious cystitis cases which occasionally follow nephrectomy and which resist all standard forms of medication I have used pure oxygen ventilation and irrigation of the bladder with gratifying results. I have been unable to find any report of this therapy being used elsewhere.

**Technique.** The bladder is completely emptied by means of a catheter and repeatedly irrigated with pure oxygen. Finally, with the bladder under slight oxygen distention, the catheter is removed. These oxygen irrigations are given at weekly intervals. During this course of therapy no germicidal solutions are used. Cystoscopic bladder examinations are done at regular intervals.

**Results.** Although the number of tuberculous cystitis cases seen at the Church Home and Infirmary is limited, I have had



gratifying results in two of our most resistant cases.

CASE I. M. T. age 17 years, was first seen on February 16, 1937, there was a history of frequency, nocturia, dysuria, and hematuria of two months' duration. Kelly air cystoscopy revealed a severe hemorrhagic cystitis with hemorrhagic areas and diffuse tubercles scattered over the trigonum and posterior bladder wall and in the region of the right ureteral orifice. The urine was loaded with pus cells, but no organisms could be seen. Bladder culture was sterile. Repeated bladder specimens were negative for acid-fast bacilli. Guinea-pig inoculation was positive for tuberculosis.

On March 3 x-rays were taken. Numerous calcified bodies were seen in the region of the right kidney and the pyelogram suggested acid-fast infection due to the "fuzzy" appearance of the right ureter. Sterile cultures were obtained from both kidneys. Urinary sediment examination from the right kidney was positive for acid-fast bacilli. Guinea-pig inoculation of urine from both kidneys was done, with the right proving positive and the left negative. Chest x-ray was negative for tuberculosis. The Wassermann and Kahn tests were negative.

On June 9, 1937 a right nephrectomy and partial ureterectomy were done. The immediate postoperative course was uneventful. Pathologic examination showed tuberculosis with cavitation at the lower pole of the right kidney, tuberculous pyelitis, and ureteritis.

The patient was discharged on June 20, 1937, but her bladder symptoms were only temporarily relieved. She was not treated locally.

In December, 1937 she complained of an exacerbation of the urinary symptoms, the frequency, dysuria, and hematuria being more pronounced. Cystoscopy showed marked ulceration and tubercle formation involving the right half of the bladder. Weekly bladder instillations of 10 per cent argyrol or gomenol in oil produced no relief. On February 11, 1938 urinary sediment from the bladder showed numerous acid-fast organisms present. Throughout the next two months the patient complained of increasing severity in her urinary symptoms. Since all of our standard treatments were of no avail, on March 3, 1938 the first treatment of oxygen ventilation was carried out and others were continued at five day intervals. On March 28, 1938 the patient stated that her symptoms had subsided tremendously. Re-

peated smears of the urinary sediment showed a marked decrease in the number of acid-fast bacilli seen. Guinea-pig inoculation of urine from the left kidney was negative. Cystoscopic examination of the bladder on April 21, 1938 showed only a small area, 0.5 cm. in diameter, still ulcerated. The previously noted ulceration and tubercle formation had subsided. Oxygen instillations were now given at weekly intervals. On April 27, 1938 the bladder urine sediment had only one acid-fast organism after extensive examination. Cystoscopy at this time showed the bladder ulceration entirely healed. On May 4 and May 10, the urinary sediment was examined and no acid-fast bacilli were seen. This patient is now being watched without treatment and is entirely asymptomatic.

CASE II. E. K., age 50 years, had had a right nephro-ureterectomy in 1934 for tuberculous ureteritis and pyelonephritis of three years' duration. This was followed by a rebellious cystitis which had been treated by the usual standard methods but without results. Nocturia, dysuria, and diuria were marked. Hematuria was variable but never massive. Urinary sediment stains showed the presence of acid-fast bacilli. Cystoscopy revealed that the right side of the bladder mucosa and trigonum were replaced by large ulcerations and conglomerate tubercles. A guinea-pig inoculation from the left kidney was negative. The bladder capacity was 300 c.c.

In September, 1937 oxygen ventilation was started at weekly intervals. In four weeks there was a marked subsidence in the urinary symptoms. Cystoscopy was done in January, 1938 at which time the ulcerations noted previously were healed but the tubercle formation persisted. The oxygen ventilation was carried out until March. There has been no recurrence of the symptoms although tubercle bacilli may be found in the bladder urinary sediment after careful searching. This patient was asymptomatic for six months.

#### CONCLUSION

The various forms of therapy offered for rebellious tuberculous cystitis following nephrectomy are so diverse that no one treatment is successful in all cases. I have used pure oxygen ventilation and irrigation of the bladder with good results in two cases. Believing this may offer an



adjunct in the palliative treatment of vesical tuberculosis this résumé is presented as a preliminary report until the merits of the method can be determined.

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TUBERCULOSIS of the arteries is the result of direct extension of ulcerative lesions in the lungs or the breaking down of tubercular glands in the chest.

From—"Peripheral Vascular Diseases" by Kramer (Blakiston).

# A CONSIDERATION OF THE SUTURE PROBLEM\*

JOHN BURKE, M.D.

Attending Surgeon, Buffalo City Hospital

BUFFALO, NEW YORK

THE existence of the suture problem is manifested by the variety of suture materials at hand as well as by the lack of uniformity in the methods of their utilization. Yet, the suture and its application is such an integral part of the surgeon's, and for that matter, the general practitioner's daily activities that it is too often taken for granted. Most of us, unfortunately, acquire our suture technique rather blindly from our elders and with it many time-honored and often time-disproved prejudices.

At present, the ideal suture material does not exist, and the materials available represent compromises. The absorbable sutures produce varying degrees of tissue reaction, and their rates of loss of strength and of absorption are far from constant. Some of the non-absorbable sutures are remarkably inert in tissue and they maintain tensile strength far beyond any necessary time interval, but, as the name implies, are of the nature of permanent guests. It is not too much to expect that the future will produce a material with the advantages of both and the disadvantages of neither. In the meantime, a knowledge of the characteristics of both types is of considerable advantage to the surgeon.

## ABSORBABLE SUTURES

Absorbable sutures are now made exclusively from animal tissues. Catgut, kangaroo tendon and preserved fascia comprise almost the entire group, although in Germany "carnofil" made from serum has had some clinical acceptance. Catgut is far and away the predominant material, and is obtainable as "plain," chromicized, iodized, tanned, or processed by combina-

tions of these methods. Huhne, in Germany, has introduced another form of processing involving certain aniline dyes, but this catgut is not available in America at present. According to its discoverer, it eliminates most of the disadvantages inherent in the use of catgut. Some of Huhne's claims have been corroborated by other observers.

Catgut's sole advantage lies in its absorbability in the body tissues, which is necessarily associated with a progressive loss of tensile strength. Chromicizing and the other processes are used in an attempt to control this loss of strength. Plain catgut loses about 90 per cent of its strength within six days, and the processed catguts within ten to twenty days, under ideal wound conditions. Many investigators, including Howes and Harvey, Jenkins, Kraissl and Inman, have shown conclusively that the optimum ten, twenty and forty day absorption rates claimed by manufacturers are subject to wide variations under clinical as well as experimental conditions. Inman, in this hospital, demonstrated that plain catgut, when placed subcutaneously in clean herniorrhaphy wounds, lost most of its strength within three to six days; forty day chromic 2 catgut similarly placed was without measurable strength within ten to fifteen days, and frequently as early as the seventh day. This is in agreement with Jenkins' work. The latter, however, found one type of chronic gut which seemed to approximate the manufacturer's claims.

It is generally recognized that wound infection markedly accelerates the rate of digestion of all types of catgut and there is some reason to believe, as does Hinton,

\* From the Surgical Service, Buffalo City Hospital.

that certain individuals are allergic to catgut and manifest this allergy by accelerated suture digestion. Clinically, the disappearance of absorbable sutures in many cases of wound disruption gives credence to this viewpoint, although the presence of subclinical infection may also be a factor. There is a suggestion in the work of Ravdin and his collaborators that protein deficiency may influence the rate of catgut digestion. The experimental and clinical studies of the increment of strength in the healing wound together with the studies of the rate of absorption of catgut, however, give sufficient information to allow the rational use of catgut under average circumstances.

Aside from inconstancy of loss of tensile strength there are several other factors which make catgut a less than ideal material. A definite foreign body reaction is seen surrounding the strands, which is more evident when the more durable, chromicized varieties are used. This is expressed clinically by the increased induration about the wound in which catgut has been used. Another disadvantage is the necessary reliance upon the manufacturer for the control of sterility. Meleney and Chatfield, Clock and the British commission have shown that catgut purchased in the open market is not invariably sterile when subjected to exhaustive test. It must be said, however, that the major American manufacturers have adopted the rigorous standards and testing techniques of Meleney and of Clock, so that the possibility of purchasing contaminated catgut in the domestic market is practically nil.

#### NON-ABSORBABLE SUTURES

There are almost as many varieties of non-absorbable sutures as there are raw materials available for their fabrication. To mention a few: silk, linen, cotton, stainless steel, silver, bronze, horsehair and silkworm gut may be purchased in the average surgical supply house and are in use in one or more clinics throughout the world. Among the metals, stainless steel

and silver are most frequently used. The other metals are used occasionally, but possess the disadvantage of causing tissue necrosis in varying degree because of chemical interaction with the tissues. In this connection it is important to realize that the term "stainless steel" includes a wide variety of alloys, many of which definitely interfere with healing. The alloy recommended by Babcock has been tested extensively and shown to be inert in tissue.

Silk is the favorite material among the non-metallic sutures, combining as it does high tensile strength, pliability and lack of tissue reaction. Many surgeons have great fear of infection in its use, but it is more sinned against than sinning. Halsted had little fear that silk, properly used, would contribute to infection. Shambaugh, reporting the results of the use of silk and catgut in herniorrhaphy over a twenty-one year period, found that infection was less frequent when silk was used, and further that infection persisted longer in the catgut series. In this study the nature of the suture material was the only variable factor.

Horsehair is frequently used in facial surgery because it can be obtained in very small diameters. It has little use elsewhere and, even in the face, may be replaced with silk.

Silkworm gut is mentioned only to condemn it. Surgical silkworm is a very poor relation of the elegant gut used for leaders, and is brittle, hard to tie securely, and seems to be irritating. Its advantage, lack of capillary action, is possessed by the metallic sutures and by processed silk and linen. Every one who has used it for tension sutures has had the discomforting experience of finding one or more silkworms broken at the time of the first wound inspection. However, its use is deep-seated in tradition and will probably continue for many years.

#### PRACTICAL CONSIDERATIONS

*Hemostasis.* As the primary purpose of any material used for hemostasis is the

closure of the vessel involved, the size of the suture required is dependent on the nature and caliber of the vessel. Either absorbable or non-absorbable sutures may be used in the non-infected wound, but catgut is usually chosen in the presence of infection. Kennedy, however, uses silk exclusively regardless of the nature of the wound.

The common error in the selection of "ties" is the use of unnecessarily heavy material. This fault is largely confined to the "catgut" school, and the influence of the silk advocates is perhaps chiefly responsible for the trend toward smaller sizes in absorbable material. Despite this, one frequently sees vessels tied off with sutures whose diameters are larger than the vessels. With the exception of major arteries, any vessel can be securely fastened with 00 catgut, and even smaller sizes are adequate for most "bleeders." Those who are accustomed to the larger sizes complain that the smaller ties break with great frequency and the complaint is not entirely unreasonable. The answer lies in the manner of tying and in the amount of tissue included within the tie. If the vessel alone is included and the knot made without terrific tension there will be no trouble. Too often we forget that the tension within the included tissue is governed by the tension of the first throw, and that the second throw merely acts as a lock for the first. Observation will reveal that most sutures are broken in an attempt to put unnecessary tension on the second knot. If extra security is needed, a transfixion suture will be adequate.

Wound Closure. The term covers a tremendous variety of situations, but intestinal suture, abdominal wall closure and skin suture will serve to illustrate the basic problems. After all, sutures are employed in any wound solely as an artificial support until the tissue union has attained sufficient tensile strength for normal activity. Consequently, the requirements for suture tensile strength and durability are governed by the tissues and the forces which tend to distract them.

The suture par excellence for intestinal work is silk, as Harvey has recently pointed out. The fine interrupted suture provides a maximum of strength, and a minimum interference with healing. If catgut is to be used, 000 is large enough and Bower's work indicates that 00000 will give even better results. In my experience a two layer suture is adequate, when interrupted black silk seromuscular sutures are used. The inner mucosal suture may be carried out with a fine running catgut stitch.

The conventional abdominal wall closure is carried out by suture of the individual anatomic layers, although Kennedy and more recently Hinton (upper abdominal incisions) advocate the "through-and-through" one layer closure. This type was abandoned generally after Billroth demonstrated the markedly lessened incidence of postoperative hernia following anatomic reconstruction. Kennedy reports a gratifyingly low incidence of wound disruption and hernia following the single layer closure. It is highly probable that complications as a result of "through-and-through" closure are less frequent than in Billroth's era, but closure layer by layer appeals to the vast majority of surgeons.

If the wound is likely to be infected, as after the incision of an abscess, or generalized peritonitis, or if there has been gross contamination intra operationem, it is advisable to use absorbable sutures. For clean wounds absorbable or non-absorbable sutures may be used at the option of the surgeon. In either case, it is most important to recognize that the only layers with appreciable tensile strength are the fascial sheaths and aponeuroses. Double zero plain catgut or very fine silk is strong enough if the peritoneum is closed as a separate layer. If the posterior rectus sheath is included, 0 chromic or silk with the equivalent tensile strength is adequate. During the past three years, I have used 00 chromic without mishap. We have demonstrated that the fascia of the anterior rectus sheath, when sutured with 0 chromic gut and placed in a tension

dynamometer, tears beyond the suture line before suture breakage occurs. If muscles are to be approximated, very fine sutures are advisable because muscle will tear long before the breaking point of the suture is reached.

Skin closure may be carried out with any fine, non-irritant material.

While the decision for or against silk is best left in the hands of the individual operator, I have been impressed by the lack of induration in the wound sutured with silk or stainless steel and, as a result, have largely abandoned the use of catgut.

The custom of using so-called tension sutures to relieve strain on the suture line has much in its favor. For this purpose, heavy processed silk, stainless steel or silver wire should be used.

The suture of faecal wounds, or wounds normally visible is most satisfactorily performed with non-absorbable materials. The advantages of high tensile strength in small diameter and lack of reaction are nowhere more desirable. While horse hair is occasionally used for this purpose, but it has little superiority over fine processed silk and its lack of uniform strength is a disadvantage.

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# RECURRENCE IN SEGMENTAL ENTERITIS FOLLOWING RADICAL RESECTION\*

LOUIE FELGER, M.D.

AND

HARRY L. SCHENK, M.D.

Attending Surgeon, Cedars of  
Lebanon Hospital

Adjunct in Surgery, Cedars of  
Lebanon Hospital

LOS ANGELES, CALIFORNIA

IN 1909 Heinrich Braun<sup>1</sup> reported on "inflammatory tumors of the intestines whose recognition is important because of their similarity to new growths." Braun found that Moynihan<sup>2</sup> had seen the condition six times in three years and that Mayo Robson had seen it five times in twelve years, never, however, involving the small intestine. It was pointed out that these tumors bore no relation to tuberculosis or to true new growths.

Since the beginning of the century and before, surgeons have encountered this inflammatory type of benign intestinal tumor time and time again and were convinced in a vague sort of way that it was in a class by itself. Attempts at etiologic determination have been made, even up to the present, by isolated workers without success, although Felsen<sup>4</sup> has reported five cases associated with the cultural and serologic findings of bacillary dysentery. In general, however, very little differentiation was made in the heterogeneous group of benign tumors of the intestinal tract, and they were all lumped together under the name nonspecific granulomata.

In October, 1932 the brilliant work of Crohn, Ginzburg and Oppenheimer<sup>5</sup> was published, establishing great order and much light in this confused, controversial field. These workers suggested the term "regional ileitis" for what they considered a new clinical entity strictly limited to the last portion of the ileum. An accurate description of the pathology was made, and several stages in the progress of the disease delineated. The most successful treatment was described as radical removal of the involved area, with ileotransverse

colostomy and resection of the short-circuited portion of bowel. Subsequent reports, however, by Crohn and many other investigators<sup>8,19,24</sup> reveal definite proof that this same pathologic process manifests itself in various parts of the small and large intestine. The etiology is still undetermined.

As understanding of the pathology increased, various workers began to feel, and justly so, that the name given to the disease by the original authors was inaccurate. Many alternatives have been suggested in the literature. The disease was first called "terminal ileitis," but when manifestations were reported in the proximal ileum, Crohn, at Barger's suggestion, changed the name to "regional ileitis." Shortly thereafter Harris, Bell and Brunn,<sup>8</sup> in reporting three cases, in one of which the jejunum was involved, offered the name "chronic cicatrizing enteritis." This was followed by the term "regional enteritis" by Brown,<sup>11</sup> and "segmental enteritis" by Lewisohn.<sup>10</sup> We believe the last to be the most descriptive term.

Segmental enteritis is a disease which suggests ulcerative colitis<sup>10</sup> in its course and manifestations, although Crohn and Rosenak<sup>11</sup> take great pains to show that there is a decided difference. The patient has a prolonged history of gastrointestinal upsets with remissions, which gradually lead to obstruction and surgical intervention. At operation in about 60 per cent of cases a mass is found in the right iliac fossa, the process most frequently, but not always, involving the last 20 to 30 cm. of ileum to the ileocecal valve. In advanced cases fistulae may be found connecting

\* From the Surgical Service, Cedars of Lebanon Hospital, Los Angeles.

adjacent portions of bowel or occasionally extending to the anterior abdominal wall. Walled off abscesses may surround these fistulae and, if drained, may lead to intractable fecal fistulae.

The pathology has certain features which are fairly constant. Although many portions of the intestine may be involved, the inflammatory process most frequently affects the last part of the ileum, and in this part is more advanced distally than proximally. Microscopically, the picture is one of nonspecific inflammation. The mucous membrane may be destroyed and replaced by an atrophic layer of epithelium. Giant cells are occasionally seen and the submucosal layers are mainly involved. In the cases in which no appendectomy had been performed (50 per cent) the walls of the appendix have an involvement similar to that of the bowel but a normal mucosa.<sup>5</sup>

The disease appears to be fairly limited to young adults with a preponderance of males of the Jewish race affected. The period of illness extends over months or years with diarrhea, fever, loss of weight and anemia almost constant characteristics. The diarrhea is the chief complaint with two or four stools a day, usually containing mucus and often blood and pus. In the obstructive stenotic cases pain, visible peristalsis and vomiting are present. The characteristic physical findings listed are: (1) scar of a previous appendectomy; (2) a right lower quadrant mass; (3) evidence of fistulae; (4) evidence of intestinal obstruction; (5) emaciation and anemia. The signs and symptoms will correspond to the stage of the disease, which may early simulate acute appendicitis and later point to stenosis and fistula formation. The stage of stenosis and intestinal obstruction is the most common.

Although the diagnosis may be suspected clinically its ultimate establishment rests with the findings in the roentgenologic examination. The Roentgen findings, according to Jellen,<sup>13</sup> are as follows: (1) stenosis of the involved bowel segment, possibly with Kantor's string sign;<sup>12</sup> (2)

non-visualization of the involved segment in some cases; (3) dilatation of the intestine proximal to the involved segment; (4) deformity of the cecum; (5) displacement of the normal small bowel by a mass in the right lower quadrant; (6) presence of fistulae; (7) evidence of associated colitis in some cases, with spasm, irritability, and localized hypermotility of the involved segment of bowel.

Segmental enteritis is to be differentiated from ulcerative colitis, ileocecal tuberculosis, fibroplastic appendicitis (or typhlitis), carcinoma of the large bowel, Hodgkin's disease, lymphosarcoma, actinomycosis, intestinal or mesenteric tuberculosis, sarcoma, and rarely, carcinoma of the small bowel.

The treatment of the condition is primarily surgical. Medical treatment is merely palliative and supportive, or preparatory for surgery. The surgical treatment of segmental enteritis has varied in the hands of different operators, and in the hands of the same operator, from simply opening and closing the abdomen to short-circuiting the involved bowel, with or without resection. From an examination of reports in the literature it appears quite generally agreed that radical resection, in one stage if possible, gives promise of resulting in the greatest number of cures.

Since accurate and sustained studies of the pathology and intestinal distribution of segmental enteritis, and its treatment by radical resection date back only eight years it is still too early to know definitely what prognosis radical resection actually gives. Koster et al.<sup>14</sup> first brought this question up in their excellent analysis in May, 1936, and at the end of the year Crohn<sup>15</sup> considered the same problem. In spite of Crohn's sanguine support of resection, citing thirty-two cases operated on by Berg with one death and no recurrences in the remainder, recurrences are taking place and reports of these are beginning to find their way into the literature. (Table 1.) The question arises, of course, as to whether

these are true recurrences or technical surgical failures.

We are concerned, in this paper, with the postoperative recurrences in segmental

Probably the first reported recurrence following radical resection was described by Moschcowitz and Wilensky<sup>16</sup> in 1923, the description of pathology agreeing

TABLE I  
REPORTED RECURRENCES FOLLOWING RADICAL RESECTION

No.	Author	Site of Occurrence	Area Resected	Interval	Site of Recurrence
1	Moschcowitz and Wilensky, 1923	Terminal ileum	Terminal ileum	1 yr.	12 inches terminal ileum proximal to anastomosis resected.
2	Coffen, 1925	Terminal ileum (?)	Terminal ileum (?)	5 mos. 8 mos.	(a) 24 inches terminal ileum resected. (b) Site? Third resection done.
3	Moschcowitz and Wilensky, 1927	Ascending colon	Lower ileum, cecum and ascending colon	5.5 yrs.	Proximal to previous anastomosis 12 inches ileum resected.
4	Crohn et al., 1932	Terminal ileum	Lower ileum, cecum and ascending colon	Not mentioned	Annular stenosis short distance proximal to anastomosis.
5	Homans and Haas, 1933	Terminal ileum	Lower ileum, cecum ascending colon	2 yrs.	Proximal loop of anastomosis.
6	Brown, Bergen, Weber, 1934	Terminal ileum and cecum	Terminal ileum and cecum	9 yrs.	Abscess and fistula. Site?
7	Musick, 1935	Terminal ileum	Terminal ileum	Not mentioned	Terminal ileum resection.
8	Shearer and Jackson, 1937	Terminal ileum	Terminal ileum and cecum	3 yrs. 8 mos. 9 yrs.	(a) Terminal ileum for 6 in. proximal to anastomosis. 10 inches ileum resected with part ascending colon and mesentery. (b) 12 inches of terminal ileum to anastomosis. Resection and ileo-transversostomy.
9	Colp, 1938	Terminal ileum	40 cm. of ileum, cecum, and part of ascending colon	2 yrs.	Terminal ileum at anastomosis. 5 yrs. after first resection 18 inches more of terminal ileum removed.
10	Felger and Schenk, 1938	Terminal ileum and cecum	Terminal ileum, cecum, ascending and part of transverse colon	6 yrs. 3 mos.	Terminal ileum at anastomosis and a portion of ileum proximal with intervening "skip" area. 24 inches ileum and part transverse colon resected.
11	Felger and Schenk, 1938	Terminal ileum	Terminal ileum and cecum	17 mos.	8 inches terminal ileum.

enteritis following radical resection. Although not all reported cases give sufficient details for analysis we have extracted from the literature all cases in point and summarize these herewith.

essentially with that outlined by Crohn and his associates in 1932. One year after a first resection it was necessary to resect another 12 inches of ileum proximal to the first anastomosis. In 1927 these same



workers<sup>16</sup> reported another case with the same pathology, but this time located entirely in the ascending colon. The cecum, ascending colon and terminal ileum were resected. About five and one-half years later the patient was operated on again and a mass was found proximal to the previous anastomosis. Twelve inches of ileum were removed and a new end-to-side anastomosis performed, using a Murphy button.

Coffen,<sup>17</sup> in 1925, reported three successive resections in one patient. This patient was a male of 20 years who, in 1916, was operated on for "appendicitis," appendectomy being done for "subacute inflammation." Abdominal exploration at this time was negative. About one month later the patient had an attack of abdominal pain, nausea and vomiting which subsided, but three weeks following this episode he was operated on for intestinal obstruction and 8 inches of "indurated bowel" were resected. Five months after this operation the patient was operated on a second time for an acute obstruction and 24 inches of ileum resected. A third resection was performed eight months following the second.

In the first report of Crohn<sup>5</sup> there is mention of an instance in which recurrent symptoms were accounted for by finding an annular stenosis a short distance proximal to the new anastomosis (ileotransverse colostomy). Apparently the resection was not sufficiently oral in location.

Homans and Haas,<sup>18</sup> in 1933, described a case in which recurrence took place after radical resection of lower ileum, cecum and ascending colon with end-to-side anastomosis of ileum to transverse colon. In this case the authors feel that lymph glands left at the mesoileum may have been responsible.

In 1934, Brown, Bargin and Weber<sup>19</sup> reported a case of radical resection which apparently was a "cure" until, nine years later, an abscess and fistula developed.

A year later, in 1935, Musick<sup>20</sup> mentions in general that "in several cases a distally resected ileum again became infected and it was necessary to do a second operation."

One of the best analyses and summaries of the entire segmental enteritis problem is contained in the report of Køster, Kasman and Sheinfeld<sup>14</sup> in 1936. In sixty-five collected cases of resection there was recurrence of the original lesion in ten cases, or 15 per cent. Of these, six patients were "cured" following a second operation, three cases were fatalities following a second operation, and one patient has had no further surgery to date (being apparently too close to recent surgery to be designated as a "cure"). In the past six years, since 1932, there have been about 200 cases of segmental enteritis reported. Radical resection tends to run about 74 per cent; sidetracking operations about 17 per cent, and in about 9 per cent of cases, mostly early, the abdomen was simply opened and closed.

In 1936, Connell<sup>21</sup> reported a rather interesting case history from his old records:

The patient was a female of 29 years.

First hospitalization, 1905. Chronic appendicitis had been present for two years and appendectomy was done at this time. The patient was symptom-free for one year, but then for the next six years she suffered from bouts of partial intestinal obstruction, occurring three to five times a year, with pain and swelling in the right iliac fossa.

Second hospitalization, 1912. The terminal ileum was thickened and enclosed in a fibrous sac. The membrane was removed, the ileum straightened out, and omentum placed over the bowel.

Third hospitalization, 1912, three months later. Ileosigmoidostomy was performed for chronic obstruction.

Fourth hospitalization, 1912, one month later. Enterostomy was done for acute obstruction.

Fifth hospitalization, June, 1913, eight months later. The lower ileum was markedly improved and localized jejunitis was the most striking finding.

Sixth hospitalization, November, 1913. Resection of the terminal ileum, ascending colon and one-half of the transverse colon was carried out. The gastroenterostomy and ileosigmoidostomy were functioning satisfactorily.

Up to 1925 the patient appears to have been all right with the exception of occasional gastrointestinal upsets.

Shearer and Jackson in 1937<sup>22</sup> reported two recurrences in a single patient.

First operation, March 31, 1923. Wide resection of ileum and cecum was done.

Second operation, November 15, 1926. The terminal ileum was involved in a process similar to the previous one. There was a well defined diseased area, beginning abruptly 6 inches above the line of the anastomosis with the colon and ending sharply at this last point. The terminal ileum was removed about 10 inches above, with the ascending colon and mesentery.

Third operation, September 12, 1935. The same gross pathology existed, well defined and sharply demarcated, beginning 12 inches above the last anastomosis and ending at the anastomosis. The mesentery was thickened and contained many enlarged lymph nodes. Another resection plus an anastomosis of ileum to transverse colon was performed. The patient was reported well fourteen months following operation.

In the first months of 1938 Colp<sup>23</sup> reported a case of recurrence:

1931, ileocecal resection, with removal of 40 cm. of ileum, cecum and part of ascending colon.

1933, x-ray showed irregularity of anastomosis of terminal ileum.

1936, patient began to complain of increasing abdominal pain.

1937, x-ray showed marked changes in the terminally anastomosed ileum, verified by operation. The ileum was divided again through healthy bowel and an ileosigmoidostomy performed. Eighteen inches of the previously anastomosed ileum was involved. The colonic portion was not involved.

#### CASE REPORTS

CASE 1. Mrs. K. R., housewife, age 41, was admitted to the Cedars of Lebanon Hospital, on November 24, 1935, complaining of nausea and vomiting, diarrhea, abdominal pain and loss of weight. She had first noticed diarrhea and loss of weight in May, 1934. In November she began to have acute abdominal pain associated with diarrhea. She was hospitalized at the Brooklyn Hospital for two weeks—the

suspected diagnosis being duodenal ulcer. The diarrhea returned and she was admitted to the Jamaica Hospital for study. X-ray showed no definite colonic pathology. There was diminished function of the gall bladder. Chest x-ray revealed evidence of primary parenchymatous calcified tuberculosis in the lower portion of the left upper lobe—apparently healed. An exploratory laparotomy done August 12, 1935 disclosed serous tubercles in the terminal ileum. Appendectomy was done. The postoperative diagnosis was tuberculous enteritis.

Following her discharge from the Jamaica Hospital, the patient was sent to a tuberculosis sanitarium at Duarte, California. The sanitarium questioned the diagnosis of tuberculous enteritis where there was no active pulmonary tuberculosis.

The patient was admitted to the Cedars of Lebanon Hospital November 24, 1935 for further study. X-ray showed the distal 4 inches of the ileum narrowed, the right kidney and colon ptosed, a lateral curvature of the spine, and phleboliths in the spleen. Barium enema showed ileocecal incompetency and narrowing of the distal 4 or 5 inches of the ileum. Sigmoidoscopic examination revealed no pathology up to 10 inches. The diagnosis was chronic terminal ileitis. Operation was done December 9, 1935. The terminal ileum was found to be hard, pipe-stem and the proximal ileum distended. Resection of the terminal ileum and cecum was done with ileocolostomy. The pathologic report was subacute regional ileitis. (Fig. 1.) The patient made an uncomplicated convalescence and was discharged to a convalescent home on January 1, 1936.

She was readmitted May 7, 1937 complaining of diarrhea, weakness, and loss of weight. She stated that she had continued to have diarrhea, had gained weight up to July, 1936 and then lost over 20 pounds. X-ray showed spasticity of the terminal loop of the ileum and transverse colon. Barium colon examination revealed patent anastomoses with narrowing of the terminal ileum of the pipe-stem variety. X-ray of the chest showed no active lesion. On sigmoidoscopic examination no pathology was found as far as the distal portion of the sigmoid. Operation on June 18, 1937 revealed the ileocolostomy functioning, the terminal ileum for 8 inches indurated and hard, with the presence of enlarged glands. A resection of the terminal ileum and the remaining portion of the ascend-

ing colon, together with a portion of the transverse colon, with side-to-side ileocolostomy was done.

of mucosa stuck up like small polypi above the areas of ulceration. Numerous lymph nodes were found at the mesenteric attachment

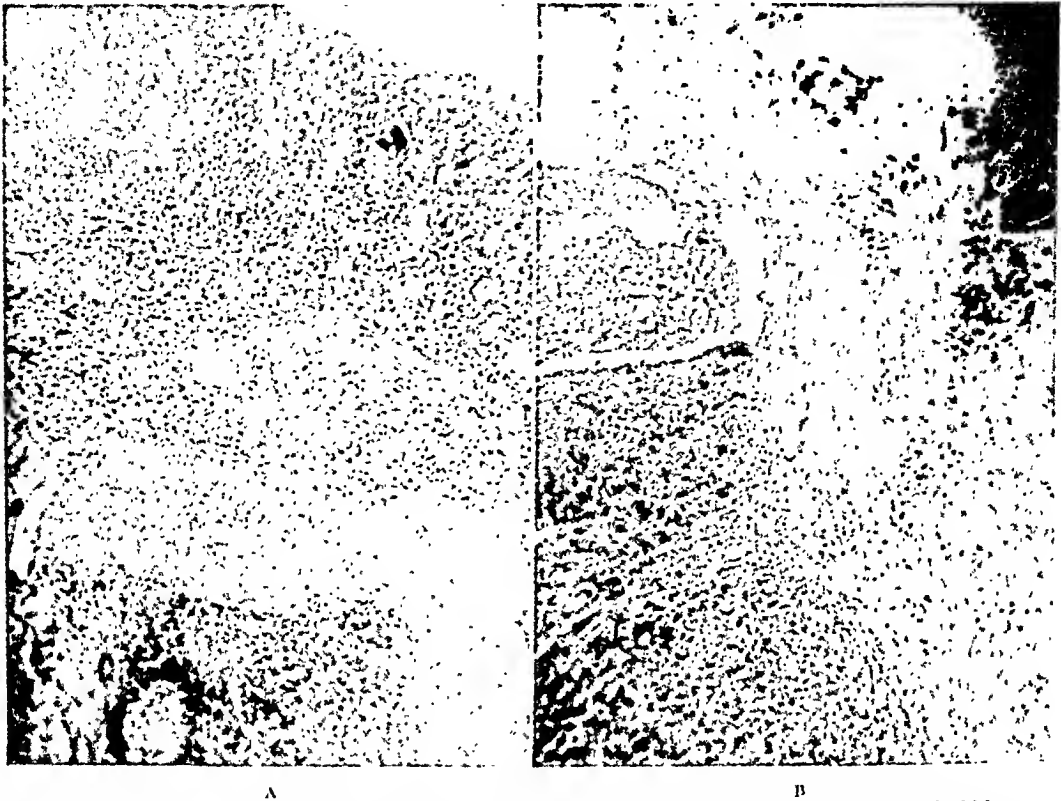


FIG. 1. Case I. A, mucosa of ileum resected in 1935, showing erosion of epithelium and lymphoid hyperplasia. B, submucosa of recurrent involvement of ileum, removed in 1937, showing lymphocytic infiltration in granulation tissue.



FIG. 2. Case II. A, recurrent larger segment measuring 26 cm., removed at operation May 27, 1938. B, specimen opened, disclosing thick edematous wall, narrowing and obstruction of lumen, normal wall and mucosa at each end of involved segment.

A pathologic report covering the 40 cm. segment of ileum showed that the middle 20 cm. were quite swollen, firm and almost completely obstructed. It was almost impossible to force fluid through the bowel. The wall of the gut was about 1 cm. in diameter and the lumen markedly narrowed. Through this area the mucous membrane was ulcerated and covered with a fibrinous exudate and surviving islands

opposite this segment of bowel. All of these were markedly enlarged, hyperplastic and, upon section, showed a wet, edematous surface. Grossly, the picture was one of ulcerative ileitis with characteristic thickening of the wall and section of the bowel.

Sections showed a segment of bowel wall which was very edematous and obviously infiltrated with round cells. (Fig. 2.) In places,

the mucosa was missing and was replaced with granulation tissue. In addition one saw numerous secondary abscesses in the submucosa.

The patient made an uncomplicated convalescence and was discharged July 9, 1937. Eighteen months after operation her condition



FIG. 3. Case II. Recurrent smaller involved segment measuring 12 cm. Findings at operation May 27, 1938. Dilated, reddened indurated loop of ileum in the left hand of the operator with contrasting loop of normal ileum held on the right.

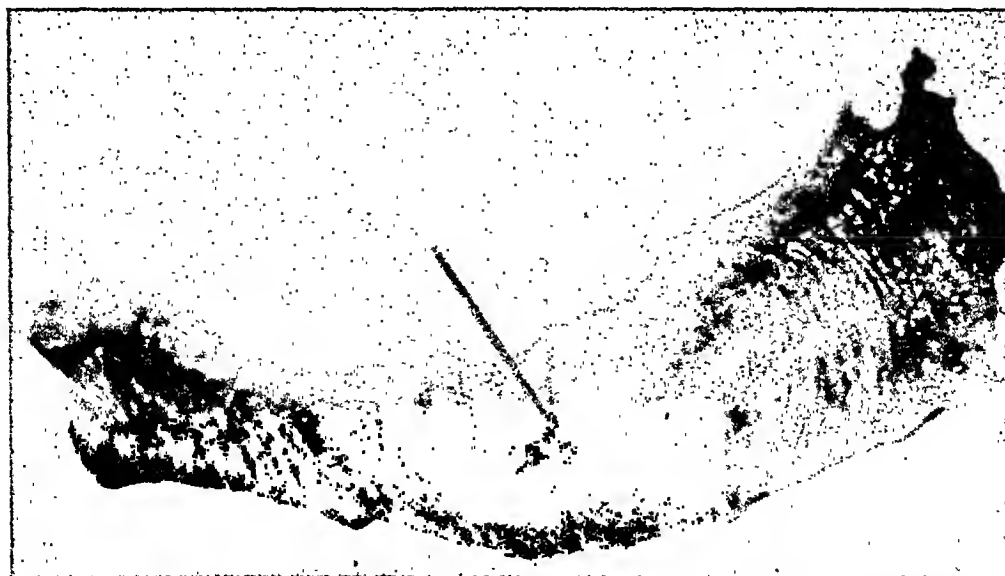


FIG. 4. Case II. Specimen in Figure 3 opened, disclosing involved area with thickening of the walls, absence of mucosal folds and normal wall and mucosa beyond involved segment.

Two of the lymph nodes were sectioned and showed marked endothelial hyperplasia with dilatation of the sinuses and filling up of the sinuses with inflammatory cells.

Subacute ulcerative ileitis was the final diagnosis.

was excellent. She had no complaints, and was on a full unrestricted diet, with no abdominal symptoms. Her weight was 108 pounds, a gain of 25 pounds.

CASE II. E. S., female, age 18, was admitted to Cedars of Lebanon Hospital, on January 30,

1938, complaining of a tender abdominal mass and anorexia. Seven years before she had complained of weakness and loss of weight. She

patient developed a fecal fistula. X-rays revealed recurrent ileitis. The fecal drainage gradually decreased and the temperature re-



FIG. 5. Case 11. Section from bowel, removed February 12, 1932, revealing marked infiltration of fibroblasts, lymphocytes, plasma cells, eosinophiles and leucocytes throughout the submucosa and mucosa.

was admitted to a hospital in Chicago in 1932 where an abdominal tumor had been discovered and operation done. A hard infiltrated mass involving the appendix, cecum and ascending colon was found. The clinical diagnosis was probable sarcoma. A resection of the terminal ileum, ascending colon and part of the transverse colon, with ileocolostomy was done. The pathologic diagnosis was "acute and chronic enteritis with involvement of mucosa, submucosa, muscularis and peritoneal surface, with production of a fibromyxomatous granulation tissue and marked proliferation of lymphadenoid tissue." (Fig. 5A.)

The patient was perfectly well until August, 1937 when she began to lose weight, had diarrhea, and later developed pain in the right lower quadrant. On January 15, 1938 she noticed an extremely tender mass in the right lower abdomen. She had frequent chills and fever, and upon admission on June 30, 1938, was extremely ill with a large fluctuant mass in the lower angle of the old right rectus incision. The abscess spontaneously ruptured several weeks after admission. Methylene blue given by mouth appeared in the dressings; the

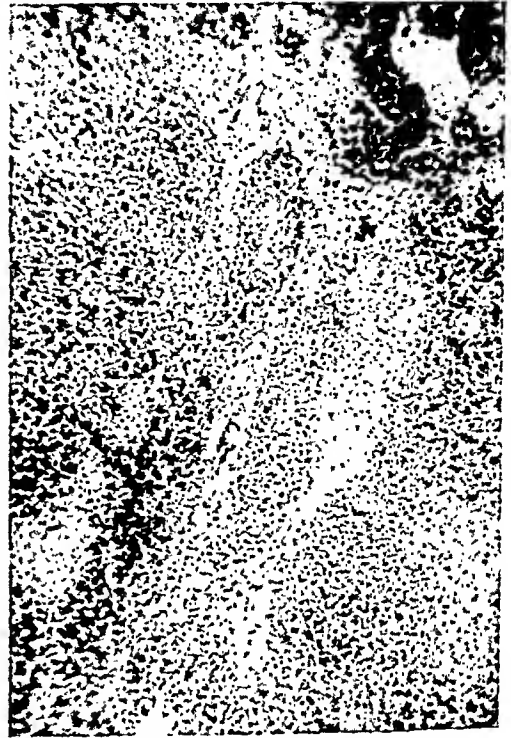


FIG. 6. Case 11. Section from recurrent segment removed May 27, 1938, showing marked infiltration of plasma cells and eosinophiles through the whole thickness of the edematous bowel.

turned to normal. The patient was sent to a convalescent home to recuperate and return for surgery.

After four months' convalescence the patient was readmitted on May 11, 1938. At operation May 27, 1938, a mass consisting of dilated reddened and indurated ileum about which the omentum was firmly wrapped was found. (Fig. 4.) Proximal to this involved portion of the ileum there was a segment of normal appearing ileum, but beyond there was another involved loop of ileum that grossly looked like ileitis. Resection of both involved areas of the ileum was done with a side-to-side ileocolostomy.

According to the pathologic report, the material consisted of two segments of small intestine, the larger measuring 26 cm. (Fig. 3.) Both were opened and the wall of the larger was thick and edematous. (Fig. 3B.) The mucous membrane contained numerous areas of ulceration. These ulcerations were elongated and looked like long clefts in the tissue. The small segment was 12 cm. long (Fig. 4) and the

central 8 cm. were involved in the same process of submucosal thickening, edema and small elongated ulcerations through the mucous membrane. The picture was grossly that of a chronic ulcerative ileitis.

Microscopic study (Fig. 5B) showed an intestinal wall which was markedly edematous. The mucous membrane in places was intact or missing, and there was marked infiltration of plasma cells, eosinophilic cells, and other round cells into the mucosa, submucosa and through the whole thickness of the edematous bowel. There was marked endothelial hyperplasia and in some of the large accumulations of lymphoid cells deep within the intestinal wall there were also germinal centers. In some places the mucosa was missing and was replaced by a slough of polymorphonuclear leucocytes. The edema, the filtration, especially of plasma cells and eosinophiles, and the endothelial hyperplasia fit in with the picture of regional ileitis.

Except for drainage and separations of the wound requiring secondary suture, the patient made an uncomplicated convalescence and was discharged August 28, 1938. Seven months later she appeared to be in excellent health and had no complaints. Bowel movements were regular, stools well formed and no diarrhea or abdominal symptoms were reported. She had gained weight, from 108 to 128½ pounds.

#### COMMENT

From a review of the cases reported it appears that following radical resection in segmental enteritis recurrences may be explained as due to one or more of the following reasons:

1. Resection insufficiently distant from the site of pathology. This category (as well as number 5) might include cases such as the one Crohn mentions in which surgery was performed through tissue which grossly appeared normal.

2. Permitting involved local glands to remain (Homans-Haas).

3. The existence of "skip" areas, pathologic areas separated by normal intestine (Harris, Ladd and others).

4. A special manifestation, or extension, of the disease ulcerative colitis.

5. Excision of an infectious, inflammatory lesion. This is not done any where else

in the body, and is usually considered unsurgical.

6. Many of the recurrences have taken place after many years of apparent cure—up to ten years. Most of the reported cures have been followed for a relatively short time.

#### SUMMARY AND CONCLUSIONS

1. The clinical and pathologic aspects of segmental enteritis have been briefly reviewed.

2. Wide radical resection is the treatment of choice, care being taken to remove "skip" areas if present, and also involved neighboring glands.

3. Reported recurrences are cited and two cases of our own added.

4. Practically all recurrences in the reported cases are at the ileal site of the anastomosis.

5. Comment is made on the apparent reasons for recurrence following radical surgery.

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# THE TREATMENT OF FRACTURED CLAVICLE IN THE PRESENCE OF KYPHOSIS BY A MODIFIED CLAVICULAR CROSS\*

GEORGE V. WEBSTER, M.D.

Assistant in Pathology, Stanford University School of Medicine

SAN FRANCISCO, CALIFORNIA

THE elderly, stoop-shouldered man or woman, or the "hunch-back" presents a difficult problem in the use of the clavicular cross. The curving of the spine renders the cross ill-fitting and painful, and all too frequently it fails to give adequate fixation. Less efficient methods of fixation such as axillary pad, swathes, slings, tapes, and particularly recumbent treatment, are most certainly to be avoided in the very aged, in whom the rounded kypnosis is usually most severe.

These difficulties are overcome by the following simple modification of the clavicular cross, easily applicable to the kyphotic patient. It consists in principle of: (1) a posterior padded plaster shell; (2) the cross board incorporated in the shell; and (3) well-padded under-arm straps. It is extremely comfortable and efficient, and weighs only  $4\frac{1}{2}$  pounds.

## METHOD

1. A trapezoid pad of thick saddle felt is cut to extend from the spinous process of the seventh cervical vertebra to the spinous process of the second lumbar vertebra. (Fig. 1A.) It is widest at the level of the spines of the scapula, where it extends within 1 inch of the acromion on either side. It tapers below to a width of about 4 or 5 inches.

This pad is carefully tailored to fit the patient, cutting out small wedges to adapt the pad exactly to the back. It may be sewed or held together with adhesive.

2. With the patient standing, the pad is temporarily fastened in place by 1 inch adhesive strips over the shoulders, suspender fashion. (Fig. 1A.)

3. A vertical splint of 8 inch plaster (eight to ten thicknesses) is applied to the felt and moulded to the back. (Fig. 1B.) Over it a transverse splint of the same thickness is applied and likewise moulded, forming a cross. (Fig. 1C.) As these splints set, two or three rolls of 6-inch plaster are applied to the entire felt pad, forming a padded shell of trapezoid shape. (Fig. 1D.)

4. With the patient still standing and the plaster shell in place, a thin board is cut for the cross, long enough to reach just inside the shoulders and wide enough to prevent axillary constriction, when the arm bands are in place.

5. With the board in the position it is to occupy, the plaster shell is marked along both top and bottom edges of the board with any sharp instrument. Remove the shell from the patient and proceed to fasten the board in place by first wrapping the board lightly in plaster, then building for it a buttress of plaster on the middle of the shell, accurately within the guide-lines. A few figure-of-eight turns secure it in place. Allow to dry about half an hour. (Fig. 1E.)

6. Meanwhile, one may make two soft, efficient shoulder straps as illustrated. A long absorbent abdominal pad of the type used in most hospitals is drawn inside a 3-inch stockinette approximately 2 feet long. This is faced with a strip of 2 inch tape of adhesive plaster and attached to the cross board, leaving one end free to be looped around the shoulder.

7. An abundant amount of sheet-wadding is placed over both shoulders running in figure-of-eight manner across the back

\* From the Department of Surgery, Stanford University School of Medicine.



and under each axilla. The fracture is reduced under local anesthesia, and while an assistant replaces the shell and holds it

9. A wide muslin bandage or elastic adhesive bandage about the lower thorax and the lower part of the cross completes

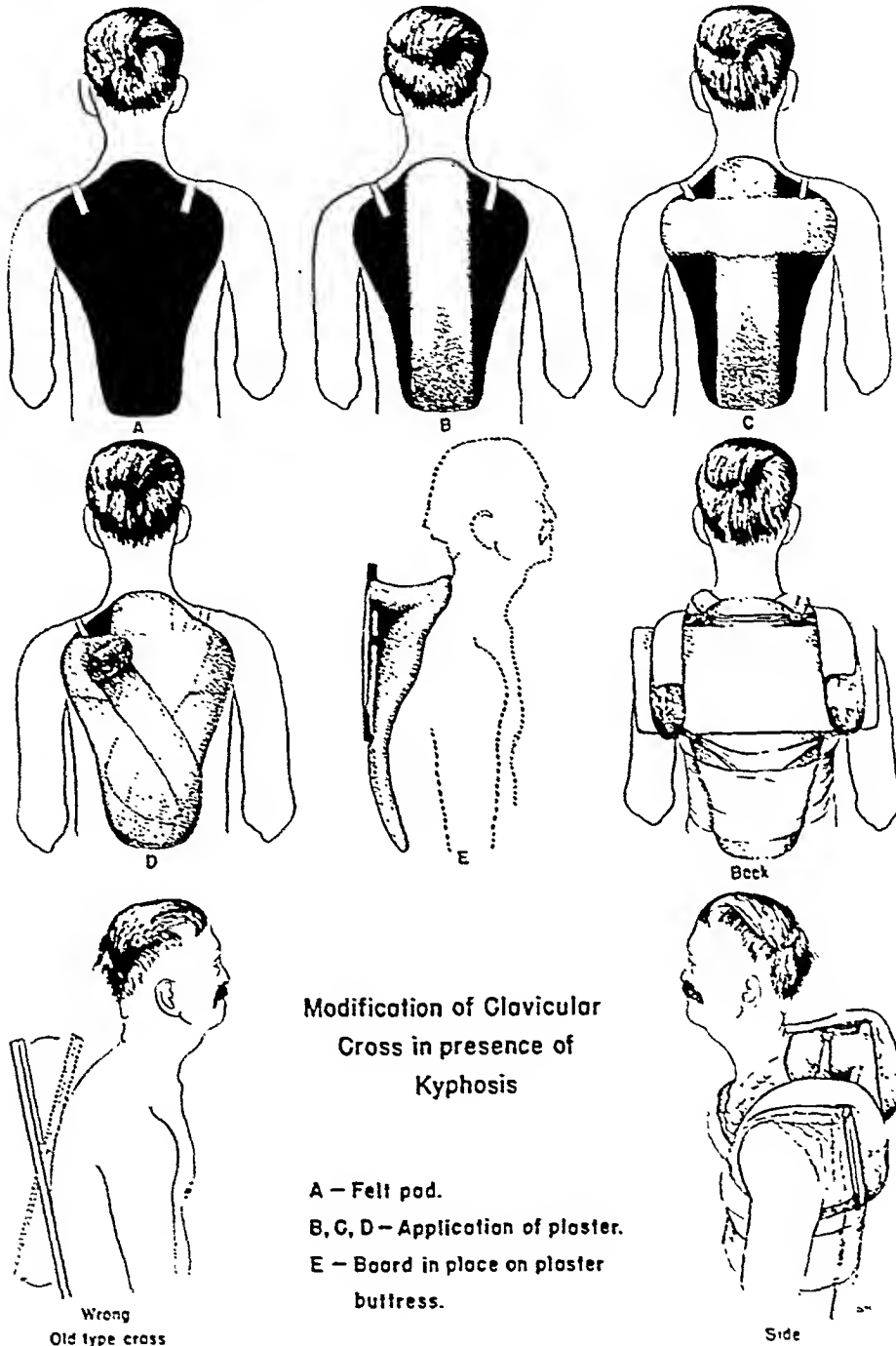


FIG. 1.

in position, the straps are looped under the axillae and fastened posteriorly to the cross board with safety pins and tape.

8. A strap of stockinette and pad is fastened across the front of the chest connecting the two loops and preventing their slipping off the shoulders.

the dressing. A vertical support to this band may be needed to prevent its slipping downward.

10. Position should be checked every other day for the first week, and should adjustments be necessary, they are simply made.



A review of the literature subsequent to the development of the author's method, reveals among all of the methods of treat-

A conventional clavicular cross was applied and maintained for eight days. During this time the patient was rarely able to sleep because of

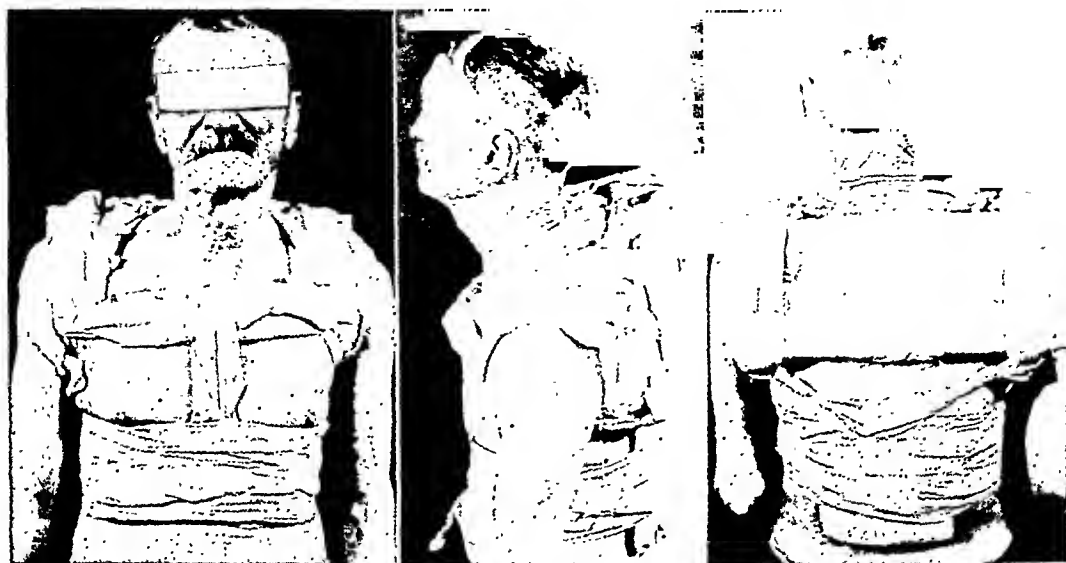


FIG. 2. Fracture of right clavicle. Modified cross had been in place three weeks, and the original position had been accurately maintained.

ment, only one article describing any similar procedure.<sup>1</sup> In this article is described a plaster slab applied in the form of a cross over a minimum amount of padding, and without the use of a buttressed cross-board so necessary to give upward, outward and backward position to the outer fragment. Furthermore, the prone position for the application of such a plaster slab seems ill-advised.

#### CASE HISTORY

Mr. J. B., aged 83, first entered the clinic on April 8, 1938, after having fallen to the street sixteen hours previous to entry, striking the point of his right shoulder. Physical examination showed a markedly kyphotic old man with an obvious fracture of the right clavicle. X-ray examination confirmed the diagnosis of fracture of the middle third of the right clavicle, with some comminution and marked displacement of fragments.

the discomfort. The cross was difficult to maintain in its proper place, and the fragments were in poor position.

On April 16, the cross was removed and reddened pressure areas were noted over the vertebral borders of both scapulae. A modified clavicular cross was applied as described (Fig. 2), and the position checked every other day for the next week. The patient was very comfortable, able to be up and about, and the shoulders were maintained in good position. The cross was removed four weeks from date of injury, and a light figure-of-eight stockinette pad support was applied. The pressure areas noted above had healed. The fracture healed in good position.

Grateful acknowledgment is made to Dr. Nelson J. Howard, Chief of Fracture Clinic; to Miss Marjorie Marsten, artist; and to Miss Ruth Goss, secretary.

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# AMMONIA AS A CELL PROLIFERANT AND ITS SPONTANEOUS PRODUCTION FROM UREA BY THE ENZYME UREASE\*

WILLIAM ROBINSON

Senior Entomologist, U. S. Department of Agriculture

WASHINGTON, D. C.

## *Ammonium Carbonate and Bicarbonate Stimulate Healing in Suppurating Wounds.*

In a recent report in this Journal the writer<sup>37</sup> has described the healing effects produced by ammonium carbonate and bicarbonate when used in treatment of chronic purulent wounds. These salts were found to be secreted by surgical maggots and to have the same therapeutic properties that the writer had previously reported for allantoin<sup>32,34</sup> and urica.<sup>33,34</sup>

When either of these ammonium compounds is applied to wounds with purulent drainage and with indolent, edematous tissues, a conspicuous change usually occurs in the condition of the wounds. The odor becomes less offensive, the thick discharge turns serosanguineous and the infection is reduced. Small islands of granulation tissue and blood vessels then begin to appear. The pallid areas become glistening and pinkish and this is usually followed in due course by a general growth of granulation tissue and final healing.

It is ammonia that brings about these results and a weak solution of ammonia (ammonium hydroxide) in water has the same effect. The carbonate part of the molecule is hydrolyzed into carbon dioxide and water.

*The Results Appear To Arise through Stimulated Growth of Granulation Tissue.* The cleansing and healing effects are not brought about through any solvent or direct bactericidal action, because in the concentrations used, namely from 1½ to 2 per cent, these ammonium salts do not possess such properties. The pyogenic infection tends to disappear, it is true, but

at the same time a vigorous growth of granulation tissue with blood supply usually forms in the wound—a condition unfavorable for bacterial activity. Effects are obtained with these ammonium compounds which are not accounted for on the basis of direct reduction of the infection, but which apparently can be explained through the proliferation of healthy granulations in the wound.

Billroth<sup>8</sup> in 1865 showed that such tissue protects the wound against the entrance of septic substances and infections. Afanasieff<sup>1</sup> later noted that it also secretes a bactericide. Arey<sup>4</sup> stated that granulation tissue “presents the ideal conditions for a defense against infections; this includes marked hyperemia, active exudation and local leucocytosis . . .”

In wounds with extensive indolent tissue, it is not uncommon to find small areas of new tissue a few days after the ammonia solution is applied. Such growth implies numerous and successive cell divisions in that period. Other factors besides ammonia could, of course, play a part in this proliferation. The mere technique of applying the treatment favors spontaneous healing. This includes the daily application of a wet pack to the wound, which is the way the ammonia solution is applied; frequent irrigations that mechanically remove debris and cleanse the wound; rest in bed. If these alone were successful in stimulating healing in chronic purulent wounds, ammonia could be considered inert. A common observation is that without changing any part of the treatment except adding

\* Contribution from the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture.

ammonia, such wounds frequently respond with healing.

*Ammonia Is Utilized by Animal Tissues in Their Metabolism.* A recent discovery of considerable value in this discussion is that animal tissues are capable of using ammonia in synthesizing amino acids which are essential in tissue growth. Euler et al.<sup>12</sup> were among the first to make such a report. They showed that bullock and hog liver preparations can synthesize glutamic acid from the  $\alpha$ -keto acid and ammonia. Rittenberg et al.<sup>31</sup> have gone still further and have shown that rats can synthesize not only glutamic acid but also arginine, glycine and aspartic acid. They fed the ammonia to rats in the food and later found that it had been taken up and incorporated into various tissues. These investigators were able to trace the identical ammonia that they had fed, as they had prepared it with isotopic nitrogen.

Glutamic acid, mentioned above, is not only essential itself in the growth of new tissues but, according to Euler,<sup>12</sup> it also occupies a central position in the general amination of keto acids to amino acids.

Previous to these studies by Euler, Rittenberg and their associates, the synthesis of amino acids was believed to be a function of plants only. Their work has therefore shown the existence of another fundamental similarity between the plant and the animal cell. Ammonia and certain ammonium compounds have been known for a long time to have nutrient and growth stimulating effects in plants.

*Ammonia from Protein Metabolism Is Not Necessarily Utilized Directly.* Ammonia formed during the metabolism of proteins might be assumed to be directly available to the cells according to their needs. Certain difficulties appear, however, in the way of this simple and easy method of obtaining it. First, ammonia from that source could be inaccessible. Its occurrence in any given tissue does not imply that it is present in or available to every cell when needed. Secondly, while each cell produces some ammonia during its own me-

tabolism, no proof exists of course that its protoplasm is ready at the same time to reutilize it. The protoplasm may be regarded as rejective and receptive of ammonia, as of other materials, according to its requirements. Moreover, the experiments of Rittenberg et al.,<sup>31</sup> already referred to, do not demonstrate that the rats utilized the ammonia directly from the food.

*Ammonia Is Producible by the Intracellular Enzyme Urease.* There is another source of ammonia, through the action of the enzyme urease upon the common metabolic product urea. Little consideration has been given to ammonia from this source; but all the essentials for its formation have been recorded for both plant and animal tissues. Also since this enzyme is readily activated and inhibited, there is the possibility of the control of its activity by the individual cells and the production of ammonia as needed. Three interrelated units are, therefore, concerned in this discussion, namely, the intracellular enzyme urease, the inert nitrogenous product urea, and ammonia which is reactive and rich in available nitrogen. Together they comprise a system in living tissues and it is with their potentialities that this investigation deals.

*Urease Is Elaborated during Cellular Multiplication.* Brunel and Échevin<sup>9</sup> in France were apparently the first to note the activity of urease at the time of cell proliferation. In 1937 they determined its activity in dormant and in germinating seeds of the plant *Agrostemma githago*, and they stated that this enzyme is absent from the dry seeds but that it is elaborated in considerable quantities during the early growth or sprouting process.

Granick<sup>17</sup> found that the concentration of urease in the jackbean is highest when the cells of the young structures are rapidly dividing and that it decreases markedly as the tissues grow older. He discussed both the formation and the destruction of this enzyme by the cells.

Coincident with rapid cell proliferation in the fungus *Aspergillus niger*, the activity of urease increases greatly, according to Bach.<sup>7</sup> When growth of the tissues is completed, the production of urease diminishes rapidly. In confirming this work, Brunel<sup>10</sup> noted that the concentration of urease had fallen over 80 per cent at maturity of the plant.

Marked variations in the production of urease were determined by Robinson and Wilson<sup>36</sup> during pupation of the surgical maggot *Phormia regina*. Extraordinary tissue changes occur in this pupal period, as the headless maggot develops into the winged fly. The larval organs are autolyzed and an entirely different set of adult organs is formed. Early in this period the concentration of urease increases 57 per cent and is followed shortly by a still greater decline. The values then rise again and finally fall abruptly when growth is completed.

It is noteworthy that this is a non-feeding period and that the tissue changes are made at the expense of existing material. Owing to the great economy necessary during that time the marked activity of urease probably renders the nitrogen in the urea available in the form of ammonia.

*Occurrence of Urease in Living Tissues.* The discovery of urease in living processes was first made in bacteria, and many species are now known to produce this enzyme. Then followed a search for it among plants with the result that it has been found in every division of the plant kingdom.<sup>16</sup> Among animals, urease is also widely distributed from insects to human beings and in various organs. This search, unfortunately, has not been intensive as little value has been attributed to its presence in the organism.

Albrecht<sup>2</sup> in 1921 detected urease in the digestive tract and in the muscles of several kinds of marine mollusks. Luck<sup>24</sup> discovered it in the gastric mucosa of the dog, cat, bullock, sheep and goat. He stated that although this enzyme is contained in the animal body, little can be said about its physiologic importance.

Loeb and Bodansky,<sup>22,23</sup> in a study of the king crab *Limulus*, found urease in considerable amount in the amebocyte tissue, blood, muscles, and eggs, and stated that the blood can easily extract it from the amebocyte tissue. They concluded that no statement could be made at that time on the function of this enzyme. Przylecki<sup>30</sup> found urease in snails, mussels, earthworms and crabs.

Steppuhn and Utkin<sup>38</sup> noted the presence of urease in the livers of rabbits, horses and dogs. They suggested that it entered the body with the food, and felt that in any case the enzyme appears to have no significance. Robinson and Baker<sup>35</sup> showed that it can be elaborated by animal tissues: they determined its presence in sterile blowfly maggots which had been reared upon autoclaved, enzyme-free food.

Majorow<sup>25</sup> found urease in hypophysis and adrenal glands, and remarked that the ovaries are particularly rich in this enzyme. Cardin<sup>11</sup> noted its appearance in the gastric mucosa of the human fetus about the fourth month. He believed its activity is limited to the stomach in connection with the neutralization of excess HCl.

In 1937 Tauber<sup>41</sup> referred to evidence of the occurrence of urease in animal tissues but believed that it had not been shown to be of importance. It is since that time, of course, that much of the information used in the present investigation has become available.

*The Enzyme Urease Is Specific for Urea.* A fact that seems to be significant is that urease can attack only urea. It is so highly specific for this metabolic product that it cannot react upon even closely related compounds. This peculiar specificity of urease early noted by Takeuchi<sup>40</sup> and Armstrong et al.<sup>5</sup> has since been well confirmed by others. It therefore appears worthy of consideration that urease, a complex protein, with a molecular weight of 483,000 according to Sumner,<sup>39</sup> exists in all types of living organisms and with no demonstrated use but to hydrolyze urea.

*Metabolic Urea Is Present in All Animal Tissues.* There is no lack of urea in animal tissues for urease to react upon; it appears to be present in all tissues and liquids. According to Andresen,<sup>3</sup> Marshal and Davis,<sup>26</sup> and Fearon,<sup>13</sup> urea occurs in approximately uniform concentration throughout the body. The content in the blood of man is from .02 to .03 per cent. Fluctuations in the urea content of the lymph and blood cause corresponding changes in the tissues. Urea is very soluble and diffusible, and the cells can absorb it readily; Gryns<sup>19</sup> finds that solutions of urea readily permeate the membranes of all kinds of cells; and Peters and Van Slyke<sup>27</sup> state that urea can pass through membranes without apparent resistance.

*Urea as a Reserve Supply of Ammonia.* Urea is known to be an inert substance physiologically and a means of removing excess nitrogen from the body in the urine. The peculiar properties of urea fit it also for another function, namely, a source of ammonia. Physiologic processes are remarkably efficient, and it is therefore difficult to comprehend that urea which so easily penetrates to all the tissues should be excretory only. A product low in solubility and diffusibility would be more effectively excreted without first permeating the cells.

"The high nitrogen content (46.6 per cent), the neutral and nontoxic characteristic, and the ready diffusibility of the small urea molecule" observe Peters and Van Slyke,<sup>27</sup> "all seem to render it peculiarly adapted to serve as a vehicle for the excretion of waste nitrogen" and, it might be added, as a supply of ammonia to the cells.

Ammonia constitutes a large part of the urea molecule and is constantly being formed during digestion and metabolism. Normally, 0.3 mg. of ammonia is said to be contained in 100 c.c. of blood. In excess it is injurious to the tissues and therefore it does not accumulate but is built up by the liver into the stable and harmless urea. This process removes ammonia as well

from circulation. If urea should have only one function, namely the removal from the body of a waste product of metabolism, it would be a strange situation to have all the tissues of the body bathed perpetually in an excretory substance.

It is not a new conception that the organism has some means of storing ammonia in a harmless form. Prianischnikow<sup>28,29</sup> in 1924 regarded asparagin as serving this purpose in plants. He went one step further and drew an analogy between asparagin in plants and urea in animals. He believed, however, that there is a difference between them in that the urea is excreted by the animal as a waste product whereas the asparagin is available to the plant.

*The Concentration of Urea in the Tissues Is Suitable for Urease Activity.* The weak solution of urea in mammalian tissues is favorable to high activity of urease. Armstrong and Armstrong<sup>6</sup> discovered in 1913 that urease works best in weak solutions, and Van Slyke and Cullen<sup>42</sup> found later that it reacts at its maximum efficiency in concentrations as low as 0.08 per cent. This applies to pure solutions of urea, and the presence of certain physiologic products slightly increases the activity of urease so that it reacts well in the normal urea content of the tissues. For instance, Jacoby<sup>20</sup> found that blood serum accelerates the activity of urease.

*The Hydrolyzing Property of Urease Is Great.* The potential capacity of urease to break down urea appears to be enormous. Van Slyke and Cullen<sup>42</sup> showed that one molecule of the enzyme can disrupt molecule after molecule of urea continuously without any measurable loss of time between contacts. Granick<sup>18</sup> has recently calculated that one urease molecule is able to split 2,000 urea molecules in one second. Fortunately, this rapid rate of hydrolysis of urea does not occur normally in living tissues; it requires not only a continuous supply of urea but also an active state of the enzyme and a rapid removal of the breakdown products.

*Inhibition and Activation of Urease.* Both urea and urease having been found in animal tissues, it follows that a coexistence of the two would imply a rigid control of urease activity. Numerous experiments in vitro have shown that urease is readily accelerated and retarded, but evidently not a great deal is known about its spontaneous control.

Armstrong et al.<sup>5</sup> found that the two end products of the enzymic breakdown of urea, namely ammonia and carbon dioxide, strongly affect the activity of urease. The authors say: "While the activity of urease is much reduced by ammonia, it is increased in a remarkable manner by carbon dioxide; in other words, the two products affect the activity of the enzyme in opposite ways—a result altogether without precedent." This has since been amply confirmed.

It is especially noteworthy that ammonia thus appears to have a dual rôle. On the one hand, it is used by the protoplasm in the building up of amino acids essential in cell proliferation, and this is supported by the ability of ammonia to stimulate growth of granulation tissue in wounds. On the other hand, ammonia is an inhibitor of urease activity and can react, conceivably, to limit its own supply within the cell. This would constitute an automatic control of ammonia formation from urea; for normal cells obviously require less ammonia in their resting period than when proliferating. It would be interesting to know if the more rapid rate of cell division in malignant growth is associated with sustained ammonia receptivity and urease activity.

*A Urease-Urea-Ammonia System in Living Tissues.* From the experiments of numerous investigators, Kiesel<sup>21</sup> in 1927 concluded: "Urea without being broken down is useless for plants, whereas in the presence of the enzyme urease it possesses an excellent nutritive value. Urea can be assimilated only after hydrolysis by living cells . . . The importance of urease becomes clear in cases where the nitrogen of

urea re-enters the protoplasm . . . One might not go wrong in expressing the same viewpoint for the animal kingdom."

Fosse, who discovered in 1912 that plants produce urea,<sup>14</sup> has also commented upon the relationship between urea and urease, as follows:<sup>15</sup> "The rôle and utility of urease in plants, unknown before our researches because the formation of urea in their cells was not known, consists precisely in the destruction of urea which is non-assimilable and the production of two excellent foods: carbon dioxide and ammonia. That is why, as we have shown, the same plant contains simultaneously urea and urease, and is the seat of two inverse phenomena, the formation and the destruction of urea."

The available data bear on the occurrence of this phenomenon in plants. The possibility of its occurrence also in animal tissues has evidently not been given as much attention.

Negative results on the presence of urease in certain animal tissues, reported by a few authorities, require investigation. For instance, Przylecki<sup>22</sup> found urease in earthworms but none in the related leeches. Owing to the minute amount of urea in any cell and the potentiality of one molecule of urease to hydrolyze many thousands of molecules of urea, it is probable that the enzyme is present in the cell in a microscopic amount in some cases, and could escape detection except by microanalysis. Also, as noted by Wilson,<sup>23</sup> the period of incubation with urea should be sufficient to allow the cells to autolyze and thus release the enzyme which of course is intracellular.

#### SUMMARY

A recent report by the writer that ammonium carbonate and bicarbonate stimulate growth of granulation tissue in wounds is correlated with other reports that ammonia is synthesized by animal tissues into several amino acids essential in cell proliferation.

In normal utilization of ammonia in growth processes, ammonia produced dur-

ing digestion and protein metabolism is not necessarily accessible to the cells. Ammonia-reception and ammonia-rejection by the cells are discussed.

Ammonia arising from the action of the enzyme urease upon metabolic urea appears to be available to the tissues. All the essentials for its formation have been recorded for plant and animal tissues. The ease with which the enzyme can be activated and inhibited in vitro raises the possibility of its spontaneous control.

Numerous reports of the occurrence of urease in living tissues are cited, and investigations by the writer and others on the activity of urease at the time of cellular multiplication are discussed.

The peculiar specificity of urease for urea, the presence of urea in all tissues and cells, and the breakdown product ammonia are correlated.

The general conception that the function of urea is to remove ammonia from the body is contrasted with the possibility that urea is also a reservoir or source of ammonia. A postulation of this type for plants is cited.

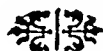
The question of automatic control of urease activity, through the inhibiting effect of its own end product ammonia and the reutilization of ammonia by the protoplasm, is mentioned as a possibility.

The conception of the reaction of urease upon urea in living tissues thus producing the nitrogenous product ammonia essential in tissue growth, is not new. Such a system has been described twice.

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# THE VALVES AND ANASTOMOSES OF THE HEMORRHOIDAL AND RELATED VEINS\*

T. F. REUTHER, M.D.

Assistant in Surgery, University of Illinois College of Medicine

CHICAGO, ILLINOIS

**H**EMORRHOIDS are the most common of all rectal disorders and, in association with their complications and sequelae, are of considerable clinical importance. They are essentially varices of the hemorrhoidal plexus. The study of the direction and rate of blood flow in the hemorrhoidal plexus is as essential in hemorrhoids as is the study of the veins of the lower extremity in varicose veins. The presence and location of valves and the degree of anastomosis occurring in the normal individual is the foundation for the study of the abnormal rate and direction of venous return.

The venous plexus in and around the rectum drains into both the portal system and the inferior caval system of veins. The submucosa of the rectum from the level of the anorectal line to the rectosigmoid junction, as well as the rectal wall above the peritoneal reflection, is drained by the superior hemorrhoidal vein, a tributary of the inferior mesenteric vein and a component of the portal system. The rectal wall below the peritoneal reflection is drained by the middle hemorrhoidal veins, and the anal canal and the area immediately surrounding it is drained by the inferior hemorrhoidal veins. Both the middle and the inferior hemorrhoidal veins are tributaries of the hypogastric veins and are therefore components of the inferior caval system.

While anatomists have agreed upon many of the anatomic facts in the study of this region, the proctologists have shown considerable disagreement as to the degree of anastomoses and as to the presence of valves in the hemorrhoidal veins. For the

foregoing reasons, it was felt that a study of the veins of the rectum and accompanying collecting veins would be profitable.

## REVIEW OF LITERATURE

In 1877 Duret<sup>9</sup> studied the rectal veins by injection methods and described small collecting veins in the anal canal, located both under the anal skin and in the substance of the anal sphincter. He also described the connections between the superior hemorrhoidal vein and those of the plexus of the prostate, seminal vesicles and bladder.

Zuckerkindl,<sup>33</sup> in 1878, described perforating veins at the anus and suggested that, since they could be injected from their central ends, they did not possess valves. He also described the connections with the prostatic plexus and the middle sacral vein.

Gay,<sup>12</sup> in 1882, during an autopsy of a patient with hemorrhoids, injected the veins and found that the prostatic plexus could be filled from the internal iliac vein, but that this injection did not reach to the superior hemorrhoidal veins. Retrograde injection of the superior hemorrhoidal vein filled its tributaries to the anorectal line, but this injection "did not even approximate the prostatic plexus." As a result of these injections, he decided that there was no connection between the portal and caval systems around the rectum.

Quenu,<sup>23</sup> in 1892, stated that, since the injection of the submucosal network from the caval system was very difficult, there must be valves in the inferior hemorrhoidal veins so placed that they would hinder passage of blood from the caval to the

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portal system, but would favor passage in the opposite direction. He also demonstrated the connection between the two systems in the peri-sphincter tissue as well as by smaller veins in the anal canal. His injections of the superior hemorrhoidal vein showed the injection mass in the prostate and the seminal vesicles.

In 1908 Ball<sup>3</sup> said: "I have not, however, by injection been able to demonstrate the free anastomosis between the two systems, which has been described by some authors."

Cripps<sup>6</sup> found that the hemorrhoidal plexus could be injected from the inferior mesenteric vein, but that this injection did not pass into the iliac veins. He believed the connection between the two systems very slight and that if it did exist it allowed flow only toward the iliac veins.

Allingham<sup>2</sup> quoted the brief report of Verneuil and stated that there was little or no connection between the several hemorrhoidal veins.

Tuttle<sup>29</sup> believed that the connection between the two systems was so narrow as to be almost imperceptible in early life, but that in old people who had been constipated and had hemorrhoids, injection of the superior hemorrhoidal vein filled the inferior hemorrhoidal plexus.

Goodsall<sup>13</sup> and Miles thought the connection between the middle and the other hemorrhoidal veins very slight.

Cooke,<sup>5</sup> Lockhart-Mummery,<sup>19</sup> Yeomans,<sup>32</sup> Pennington,<sup>20</sup> and Gant<sup>11</sup> say that there is a free communication between the two systems in the region of the rectum. The anatomists Waterson,<sup>30</sup> Robinson,<sup>24</sup> Piersol,<sup>21</sup> Lewis,<sup>18</sup> Tandler,<sup>27</sup> Senior,<sup>25</sup> and Testut<sup>28</sup> all describe a free communication between the two systems at the rectum.

In considering the question of the presence of valves in the hemorrhoidal veins, Senior<sup>25</sup> notes that the superior hemorrhoidal vein, being a tributary of the portal system, is without valves. Piersol concurs that the portal veins are without valves, "although the opposite view is held by some."

Crisp,<sup>7</sup> in 1855, reported finding valves in the portal systems of many lower animals and Franklin,<sup>10</sup> in 1926, found valves in the portal vein of the sheep.

Hochstetter,<sup>15</sup> in 1877, saw valves in the portal systems of lower animals, in newborn infants and less frequently in adults. He studied the veins of the gastric region and reported that the valves were constructed in the same way as those of the caval system, but were so slight that they were easily forced by injection. He concluded that these valves atrophied with advancing age.

Bryant,<sup>4</sup> in 1888, confirmed the findings of Hochstetter and reported finding valves in the veins of the human intestine. Wilkie<sup>31</sup> demonstrated the presence of valves in the tributaries of the gastric, omental and colic veins of animals, infants, children and adults and suggested that, since they were less numerous in the aged than in the newborn, they were undergoing a retrograde metamorphosis. Neither of these authors reported specifically on the tributaries of the superior hemorrhoidal veins. Lewis, Robinson, Porier,<sup>22</sup> and Testut all state that there are valves in the portal system in the embryo and newborn, but that they atrophy in the adult.

Valves were stated to be present in the inferior hemorrhoidal veins by Agnew<sup>1</sup> and Cook. Senior, in discussing the tributaries of the hypogastric vein, states that the superior and inferior gluteal veins have valves as do the lateral sacral and ilio-lumbar. He does not mention the middle or inferior hemorrhoidal veins.

#### OBSERVATIONS

*Material.* Among the comparative animals, the material consisted of three dogs, examined in the recent state, and one macaque rhesus. In the human the veins were examined in the cadavers of eighteen infants and eight adults. There were also examined four specimens removed at autopsy. The adult human bodies were intact or partially dissected prior to the

examination. Both male and female human specimens were used.

*Methods of Study.* The veins of these

always protected, as were the hypogastric trunks and all the mouths of the tributary veins emptying into them. Injection of the



FIG. 1. Valve at the junction of the superior hemorrhoidal and last sigmoid veins in the newborn. ( $\times 330$ .)

specimens were examined by direct dissection and by microscopic examination of sections. Injections of Roentgen opaque and colored masses, using gravity or thumb pressure on the ordinary Luer glass syringe, allowed study of the vessels by stereo-roentgenogram as well as by making transparencies after the method of Spalteholz.<sup>26</sup>

*Observations on Animals.* In the dog the portal vein tributaries are well provided with valves. None were found in the main portal trunk, but the ostia of the splenic, gastric and pancreatic veins were all guarded. The vena breva of the stomach contained valves as well as the small veins of the intestines. There were many atrophic or incompetent valves present in the various vessels. At the junction of the superior and inferior mesenteric veins there were arcuate white lines visible on the vein walls but no leaflets were present. The common iliac veins contained valves in some instances, but the external iliac veins were



FIG. 2. Retrograde injection of the inferior vena cava of the newborn showing competent valves in the veins of the pelvis that prevent filling of the anorectal region as well as the vesicoprostatic plexus. Great pressure causes filling of the sacral and entire vertebral plexus and later the inferior vena and renal vein above the site of injection.

portal system demonstrated valves competent to resist back pressure in the gastric and colic small veins. Of special interest was the finding of a competent bicuspid valve in the distal portion of the superior hemorrhoidal vein in two of the three dogs examined. This valve was capable of resisting pressure great enough to allow injection of the entire bowel mucosa above the site of the valve.

In the monkey there were no valves present in the larger tributaries of the portal system, and as the animal had died of peritonitis the bowel wall was so involved that study of the smaller tributaries was impossible. It was possible to inject the superior hemorrhoidal vein and the colored mass was easily visible down to the ano-

rectal junction but did not extend across the anorectal line. With the left common iliac clamped the left femoral vein was

vein could be filled but that the veins from the prostate and outside the rectum—the middle and inferior hemorrhoidal veins—

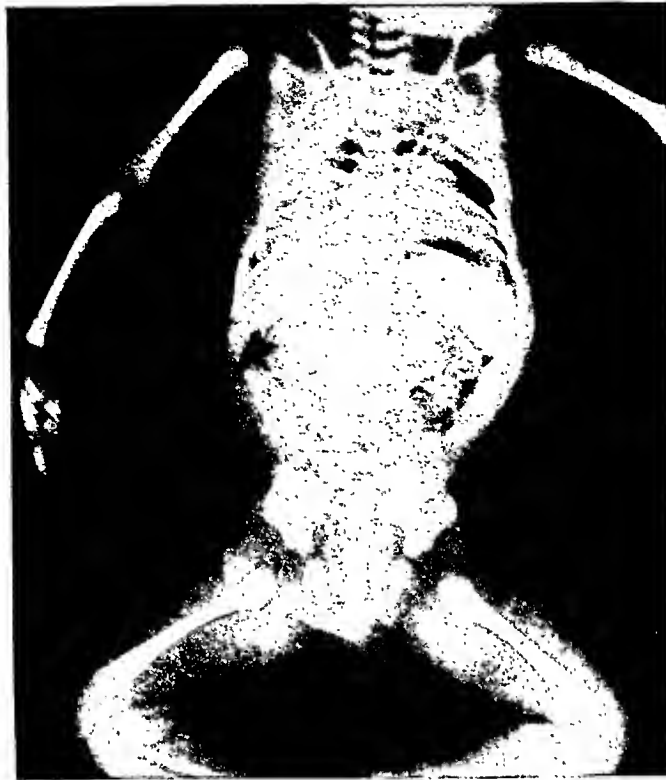


FIG. 3. Injection of the portal system in the newborn. Great pressure was used and the superior hemorrhoidal vein filled but the middle and inferior hemorrhoidal veins did not.

injected with a considerable amount of force and two small inferior hemorrhoidal veins were filled so as to become visible on the perineum on the left side. Dissection of the pelvis then showed that there was some discoloration of the rectal wall on the left side from the injection of the femoral vein and that this extended into the wall of the rectum and into the submucosa above the anorectal line in several places. Apparently there was some connection with the middle hemorrhoidal group of veins that allowed this to happen. The opposite side of the pelvis showed no filled veins and demonstrated the absence of a free anastomosis between the veins of the two sides of the pelvis. At a later time it was observed that in an experiment in which Dr. Batson was injecting the deep dorsal vein of the penis of a living monkey with thorotrast, the internal iliac as well as the external iliac

did not fill as did the lateral sacral and obturator veins. This suggested that the mouths of these tributaries were guarded by valves.

*Observations in the Newborn.* The portal vein and its larger tributaries contained no valves. In several bodies there were white lines at the junction of some of the larger tributaries, but no cusps were present. It was noted in four bodies that lines were located at the junctions of the superior hemorrhoidal with the last sigmoid vein. In one specimen there seemed to be a competent valve here that would resist retrograde stroking and this was ligated and removed. Microsections made by the Department of Pathology demonstrated the competent valve at this point. (Fig. 1.)

In general the valves of the newborn were more constant in their locations in the pelvic veins of the inferior caval system and

it was also noted that these were always more competent to resist retrograde injection that was the case in many of the



FIG. 4. Injection of the deep dorsal vein of the penis of the adult with filling of the vesico-prostatic plexus and the large veins on the lateral walls of the pelvis. There is no filling of the veins in the anorectal region.

corresponding veins in the adult. Figure 2 shows an x-ray film made after the injection of the inferior vena cava. There are valves in the common iliac veins that resist pressure sufficient to fill the entire vertebral plexus. In no instance, using both fine and coarse masses, was it possible to fill the inferior or middle hemorrhoidal veins in a retrograde direction by injection of the femorals, the vena cava or the internal iliac veins. No color would appear in the prostate or rectum although the sacral veins could be filled by exerting considerable pressure.

Injection of the portal vein of the newborn would always first fill the gastric region, the spleen and the pancreas. In some cases there were bulges at the openings of the tributary veins along the greater curvature of the stomach and along those

of the colon. Slight increase in pressure would always force the mass past these areas. The entire system could be filled, but by the time that the mass would appear in the lower colon and rectum the entire bowel wall of the upper intestinal tract would be injected. (Fig. 3.)

Anastomoses between the portal and caval systems around the rectum were demonstrated in only a single instance. The prostatic plexus and the sacral veins were filled only after great pressure was used and then the veins filled so poorly that they did not show on x-ray examination and were only found by dissection.

In one instance, where filling of the pelvic veins occurred following injection of the portal system, a dilute india ink mixture was used. The filling was not observed as the fluid was flowing by the gravity method under a pressure of 150 mm. of water. It was only after the injection had been completed that the outer rectal plexus was seen filled and the possibility could not be eliminated that it might have filled through some other upper abdominal route since the vertebral plexus was also filled.

The valves at the mouths of the tributaries of the hypogastric vein were not shown by x-ray examination as the veins were so small that they could not be satisfactorily demonstrated. However, it was possible to show that those veins did not fill after injection as they should have, had there been an avenue for retrograde flow unimpeded by valves.

*Observations in Adults.* One was struck by the many variations in size and location of valves in the pelvic veins in the adult. In most instances when the right and left halves of the pelvis were examined, there was decided difference in the two sides of the same body. In general there were no valves in the inferior vena cava, the common iliac and the hypogastric veins. There was a valve present in the external iliac vein in many cases, but in no instance was it competent to resist the back flow of blood caused by stroking and it never

blocked the injection mass. There was usually a valve below the femoral junction and at the junction of the obturator and

would drain into larger veins on the lateral walls of the pelvis; the external iliac vein only rarely, the internal iliac vein almost

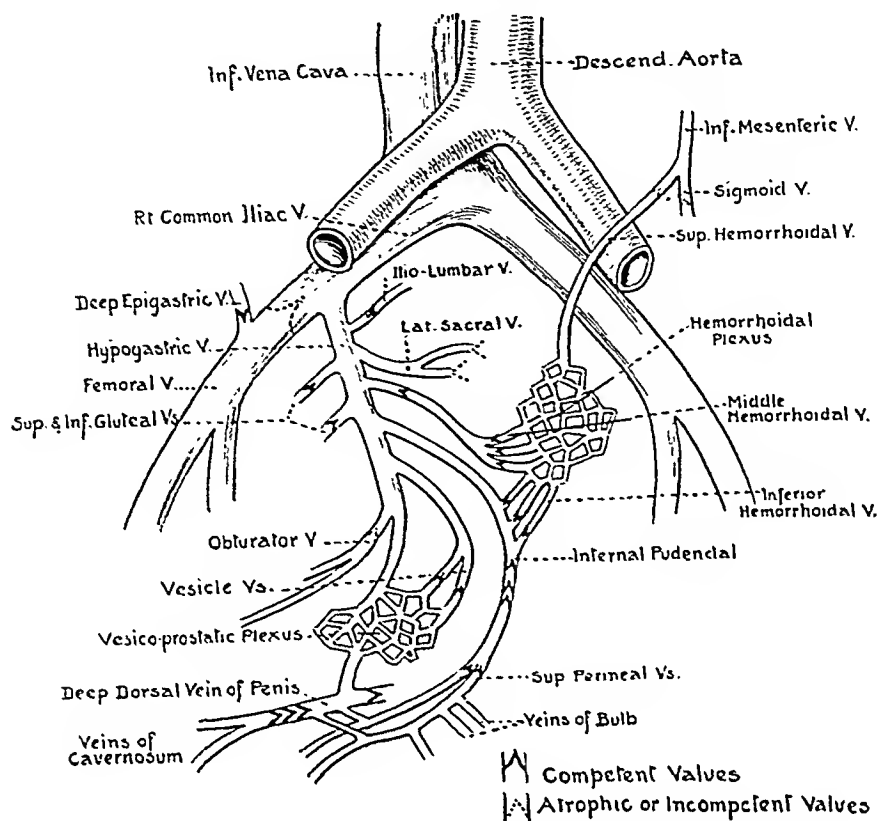


FIG. 5. Diagram of the pelvic veins showing the usual sites of competent and incompetent valves, as demonstrated by dissection and injection.

the deep epigastric veins. The tributaries of the hypogastric vein were protected by competent valves in almost all instances.

Injection by way of the deep dorsal vein of the penis which usually contains several sets of valves caused no filling of the middle or inferior hemorrhoidal veins. The valves at their mouths could be seen as definite bulges on x-ray examination. Valves were also noted guarding the superior and inferior gluteal, the ilio-lumbar, and the vesicle veins. The internal pudendal vein was sometimes guarded by competent valves and sometimes not.

The gross dissections demonstrated valves in the pudendal vein regularly, but they were apparently not always competent. In no instance was it possible to fill the hemorrhoidal plexus or prostatic plexus by injection of the femoral vein. The prostatic plexus could be filled by injection of the dorsal vein of the penis and this

constantly, and the lateral sacral vein in varying degree almost constantly. The rectum was never injected, not because there was no connection with the hemorrhoidal plexus from the middle or inferior hemorrhoidal veins, but because the distal ends were protected by valves that did not allow them to fill. (Fig. 4.)

Dissections showed that there were frequently several sets of valves in the internal pudendal and at the mouths of the superficial perineal veins as well, even though these could not be injected because of the valves more centrally placed. It might be well to add that there were also valves at the smaller tributaries of the gluteal veins as well as in the subcutaneous veins of the scrotum and perineum. These were well marked and apparently competent. This finding shows that not only are the mouths of the main tributaries of the hypogastric vein protected but also the smaller tribu-

aries of these veins. The diagram in Figure 5 shows the locations of the valves found in the pelvic veins.



FIG. 6. Section through the cup of well-developed valve found in the superior hemorrhoidal vein of an adult. (X 25.)

The portal system of man shows no gross valves on dissection in either the main trunk or its larger tributaries. There were only six competent valves found in one body injected with a thick barium sulfate suspension. These were in the gastric, the ilioocolic and left colic regions. In one body examined there were marks left from the atrophy of a set of valves in the superior hemorrhoidal vein at the junction of this vein with the inferior mesenteric. In one specimen removed at autopsy there was a competent bicuspid valve found when the vein was opened with scissors. This segment was removed and a section made through the leaflet of the valve. (See Fig. 6.) The body from which this vein was removed was not examined at autopsy for hemorrhoids but the hospital record made no mention of finding hemorrhoids on physical examination. No other valves were found in the superior hemorrhoidal veins examined.

Injection of the portal system in adults showed the same features noted in the case of the newborn. The upper portion of the



FIG. 7. Retrograde injection of the superior hemorrhoidal vein in an adult body. Note the filling of the network of veins in the submucosa in the lower rectum and in the filling of the middle hemorrhoidal veins. The inferior hemorrhoidal veins are hardly visible.

system filled first, as did the spleen and pancreas. The larger trunks filled readily and there were no valves shown in the main tributaries after injection. The injections made with little pressure did not fill the superior hemorrhoidal vein satisfactorily. It was injected directly and the tributaries could be made out. In those injected with considerable force the injection mass showed a fine network of veins at the anorectal region as well as two or three main trunks from this area. In the bodies with no gross evidence of hemorrhoids there was only slight filling of the caval veins from the superior hemorrhoidal vein. In one body, where there were definitely visible externo-internal hemorrhoids, the injection of the superior hemorrhoidal vein filled the plexus in the rectum



and then extended into the pelvic veins on both sides. This was first noted on the subsequent x-ray examination and again when the thighs were disarticulated. This had taken place through the middle hemorrhoidal veins as there were only a few fine shadows at the anal margin. (Fig. 7.)

Examination of the submucosal veins in the lower half of the rectum showed that there were large veins into which were drained the much smaller veins from the anorectal region. These occurred in the region of the lower valve of Huston. In two of the adult bodies examined these veins were tortuous and ran in a direction at right angles to the lumen of the rectum. These veins were adherent to the mucosa when this was dissected from the muscular coat of the rectum and the many small veins that drained the muscularis into the submucous veins were divided. Figure 8 shows a portion of the removed anal skin and the rectal mucosa to show the location of the larger collecting veins that drain both the interior and the exterior of the rectum. The large veins present in the region so far above the hemorrhoidal area seemed to be the chief site of communication between the superior and middle hemorrhoidal veins. As they were so much larger than the veins in and around the anal canal, it seemed that in cases of portal obstruction these veins should be larger than the frequently noted hemorrhoids in the anorectal region. Examination of two cases of portal cirrhosis, one with gross externo-internal hemorrhoids and the other without, showed these enlarged tortuous and typically varicose veins. A similar case had been examined in the gastroenterology clinic some years before. At that time the examiner made the note that there were hemorrhoids present but that there were markedly enlarged veins visible in the lower 3 inches of the rectum.

#### DISCUSSION

This small series seems to show that there is a progressive atrophy with increasing age of valves in the portal system, com-

parable to that described for the other veins of the body. The increase of the width of the veins themselves seems to parallel



FIG. 8. The venous tributaries of the superior and the middle hemorrhoidal veins located in the rectal submucosa viewed by transmitted light.

the degeneration of the valves. This increase appears greater than would be expected from the growth of the body. The increase in caliber is associated with the increase of the anastomoses between the portal and caval systems around the rectum. This process may be similar in all persons, but it is possible that there is in certain families a definite hereditary weakness of the hemorrhoidal vein walls as suggested by Curtius<sup>8</sup> and Gutman.<sup>14</sup> The normal process would explain the fact that hemorrhoids are rare before puberty and why the incidence increases with age.

#### SUMMARY

1. The dog shows both competent and incompetent valves in the portal venous system. Two of the three bodies examined had competent valves in the superior hemorrhoidal vein.



2. The hemorrhoidal plexus in the macaque rhesus monkey resembles that in the human. No valves were found in the larger tributaries of the portal system.

3. The newborn infant has valves in the smaller portal tributaries of the gastric and colic regions. The sites of atrophic valves were noted at the mouths of the superior hemorrhoidal veins. The middle and inferior hemorrhoidal veins were protected by competent valves. The degree of anastomosis between the caval and portal systems is slight.

4. The adult has less numerous valves in the portal system. In one body there was a well developed valve in the superior hemorrhoidal vein. The central ends of the middle and inferior hemorrhoidal veins were protected by competent valves.

5. The degree of anastomosis between the portal and caval systems increases with age and is more marked in bodies showing well developed hemorrhoids.

6. The chief site of anastomosis is between the superior and middle hemorrhoidal veins and occurs in the rectal submucosa well above the anorectal line.

7. In cases of portal obstruction varix formation occurs in these veins in the rectal mucosa and these varices are visible on proctoscopic examination.

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# POLYCYSTIC KIDNEY DISEASE\*

HARRY HAUSMAN, M.D.

Assistant Visiting Surgeon, Harlem Hospital

NEW YORK CITY

**P**OLYCYSTIC kidney disease is of interest because of its rarity and because it is frequently overlooked. However, in the autopsy room it is striking and spectacular.<sup>1</sup> I have personally studied five cases, two of which came to necropsy.

In Harlem Hospital there were 67,000 admissions during the years 1930-1935, and only five cases came to light, a ratio of 1:13,400. Statistics, however, show that in 23,900 autopsies, sixty-seven cases of bilateral polycystic kidney were found. In Dr. Gordon B. Oppenheimer's<sup>2</sup> series at Mt. Sinai Hospital there were sixty proved cases in 220,000 admissions, a ratio of 1:3500; in 6000 necropsies fourteen cases were encountered, or a ratio of 1:428. The Mayo Clinic had an incidence of 1:3,523 in 680,000 registrations, and of 1:1,019 in 9,171 autopsies.

Bugbee and Wollstein<sup>3</sup> found four unilateral and eleven bilateral cases in 4,903 necropsies in infants. Ritchie<sup>4</sup> found two in eighty-eight cases autopsied.

Simple palpation at operation alone cannot be relied upon for proof that the non-nephrectomized kidney is normal, despite clinical reports to the contrary. It is an important surgical fact that when nephrectomy has been done for polycystic kidney in a case in which the second kidney had appeared normal to the surgeon's palpating hand, the latter kidney is very likely to become polycystic subsequent to the operation. Braasch and Schacht<sup>5</sup> state that polycystic kidney is always bilateral in the adult.

It is my impression that there are many more cases of this disease than our statistics show. Some cases never come under our observation because of lack of symptoms and death occurs due to some other

cause; others are overlooked because they may have symptoms other than urologic. Associated complications may mask the entire picture. The clinical symptoms may be entirely those of nephrosclerosis and hypertension.

In one family under my observation, the disease occurred in three sisters, one brother and one nephew. They called themselves the "kidney family." The symptoms were all of the chronic interstitial type. In two cases the kidneys were clinically cystoscopically and roentgenologically polycystic. Two died from cerebral hemorrhages. The nephew, 45 years old, has hypertension.

Thorington<sup>6</sup> also has cited five cases in one family, all of the same parentage. These patients died between the ages of 30 and 50.

The disease probably follows Mendel's law of inheritance. It may occur in successive generations; only a single member of some family may have it, while in other families several may have it.

The most generally accepted theory of etiology is predicated on the assumption that the secretory and collecting portions of the kidney, developed from two different layers of the Wolffian system, subsequently unite to form a channel. A failure to join would then be responsible for the cysts. Cysts found in other organs, in my opinion, are associated manifestations.

Virchow thought that obstructions of the tubules due to uric acid and lime deposits or to inflammatory changes at the papillae led to cystic development. Shattock believed that the cysts developed from cells of the Wolffian body remnants. However, the most generally accepted theory of imperfect development is that

\* From the Surgical Service, Harlem Hospital, New York City.

founded in the dualistic theory of renal genesis.

Recently Beeson<sup>7</sup> has attempted to explain this failure of union as the result of a relative poverty of secretory nephrogenic tissue and atypical growth of the more abundant tubular collecting and vascular elements. Davis<sup>8</sup> assumes that polycystic kidney results from a delay in development and differentiation with subsequent cystic changes caused by an inherited defective protoplasm.

The adult form results from persistence of fetal maldevelopment with interstitial nephritis, and is related to granular cystic kidney. A kidney may be considered polycystic when there is an excessive number of small and large cysts throughout the parenchyma and projecting on the surface. Both cortex and medulla are involved. The cysts do not communicate with the pelvis, although on occasion one may rupture into it. Arteries of varying size line the walls of the cysts, separated by a thin layer. Their rupture causes hemorrhages and resulting attacks of pain, and hematuria. Perirenal hematomas have followed rupture on the surface. A large amount of fairly normal parenchyma may remain or there may be a complete gross absence of renal tissue, depending on the stage reached.

*Clinical Classification.* There are two forms of polycystic kidney, the newborn and the adult. The former, more often seen in maternity hospitals, is frequently associated with various other congenital anomalies, such as hypospadias, cleft palate, harelip, spina bifida, etc. While anomalies occasionally occur in adults, they are not common.

In many of the newborn cases death occurs at birth or shortly after. In the rest the condition goes unrecognized and the patients reach adult life before presenting any signs. A few infants live to develop symptoms or die of intercurrent disease before the age of 2 or 3 years. In such instances, the syndrome of renal rickets in renal dwarfism may be present.

In the group here described the ages ranged from 28 to 44 years. Four were females and one male. They were all bilateral cases. In three cases associated or superimposed tuberculosis could not be ruled out, but radiographically polycystic disease was diagnosed.

Braasch and Schacht<sup>5</sup> and others have commented on the frequency of significant persistent hypertension in these cases. They attribute the hypertension to a generalized vascular disturbance as shown by the high incidence of retinal sclerosis and to the findings of obliterative changes in the arterioles and small arteries of the kidneys. Whether the vascular sclerosis, especially in the kidneys, is the primary factor and the hypertension and renal functional disturbance secondary, is a moot point. In our series, three cases had hypertension and associated symptoms, such as paralysis of the upper extremity.

*Kidney Reserve.* Experiments in animals, producing varying reduction of the total renal substance, while not conclusive, have shown that where a chronic state of renal insufficiency is produced, hypertension and cardiac hypertrophy result, without vascular sclerosis. Goldblatt,<sup>9</sup> in his recent publication on experimental hypertension due to renal ischemia, states that this type of hypertension can be produced at will by constricting both main renal arteries by means of a special clamp or by constricting the main artery of one kidney and removing the other kidney. After several years, the small arteries and arterioles show some thickening of the media and sometimes slight hyalinization of the intima, especially in retinal arterioles. This type is similar to the benign phase of human essential hypertension.

In the early stages of polycystic disease, renal impairment is not clinically evident and is found only by urologic studies of the concentrating powers of the kidney, phenolsulfonephthalin and blood chemistry tests. Patients with polycystic kidneys can

go about with marked azotemia yet without pronounced clinical signs and in apparent good health. It has been amazing to note in such patients an extremely high blood nitrogen figure and hypertension for several years before uremia occurs. This is accounted for in part by the good kidney reserve.

The hemoglobin falls because red blood cells are excreted in the urine in large quantities.

*X-Ray Studies.* Retrograde pyelograms are preferred with non-irritant solutions such as hippuran 40 per cent, and neoiopep 30 per cent. Intravenous pyelography is not advisable, especially where there is high blood chemistry. There is usually poor excretion of the dye because of impaired kidney function. This may further embarrass an already impaired kidney and cause an additional toxemia due to retained iodides. The pyelogram characteristically shows: (1) shortening or obliteration of one or more of the calices, producing an oval or irregular squared pelvic contour; (2) encroachment with compression of one or more calices by cysts, causing them to assume a circular or semicircular outline and change in position of the axis of the pelvis; (3) stretched-out, spidery shape with sharp lines instead of the soft, curving lines of the normal contour; (4) obliteration of the pelvis as the result of extension or compression of cysts. The kidneys are usually enlarged and irregular.

*Diagnosis.* Typical cases present a history of loin or abdominal pain, hematuria, nocturia and loss in weight. Unilateral or bilateral loin masses are noted, together with hypertension and laboratory evidence of renal impairment. A familial history is corroborative. A constant positive Mosenthal is usually present. The pyelogram is decisive.

Three types of infection are seen. In one type there is pyelitis, pyelonephritis or infected hydronephrosis, any of which may be secondary to moderate obstruction at the pyeloureteral junction by the pressure of the cysts. There may be associated

calculi. The second type shows purulent infection localized to individual cysts. The third type is a diffuse purulent infection of the residual renal parenchyma, as well as of the cysts, with occasional complicating perforation and perinephritic abscess.

#### CASE REPORTS

**CASE 1.** F. B., female, age 31 years, colored, was admitted December 1, 1935 with a diagnosis of pulmonary tuberculosis, polycystic kidney disease and ventral hernia.

In March, 1934 the patient complained of knife-like pains under the right scapula, later involving the anterior part of the chest. The pains were increased on deep breathing. She was acutely ill with a temperature of 104, pulse of 116 and respiration 26. Blood pressure was 110/60. A provisional diagnosis of lobar pneumonia and acute fibrinous pleurisy was made.

On March 16, the patient coughed up dark red, thick, foul sputum. Physical signs of abscess cavity were present and a tuberculosis test was positive. Bilateral tender masses in the flanks were palpable three days later. Kidney pathology was suspected, but the patient was too ill for urologic study. On April 26, operation was done for abscess in the right upper lobe of lung. The blood count was 30,000 leucocytes, with 74 polynuclears and 23 lymphocytes.

On December 3, 1934, the patient was readmitted to the hospital with complaints of cough and pains in the right side of the chest, radiating to the back. No genitourinary symptoms were noted. The thoracotomy wound was still draining, and there were pains in the right side of the abdomen, more marked in the right upper quadrant. Our impression was that there was a subdiaphragmatic metastatic abscess, possibly cholecystitis or kidney infection.

On December 19, 1934 a cystoscopy was done and catheterization of ureters. The cystoscope was passed with moderate difficulty due to a Bartholin gland abscess. The vault of the bladder was flattened due to pressure, the trigone appeared raised, and trabeculae were present in the base. The ureteral orifices were closely set, but normal in appearance. The left catheter passed up to 30 cm., the right to 20 cm. Cloudy urine was obtained from the left side and later red blood cells appeared. There was no flow from the right after a wait of twenty minutes. After intravenous injection

of 5 c.c. of indigo earmine, no dye came from the right; on the left dye appeared in twenty-four minutes, but of poor concentration.



FIG. 1. Case 1. Pyelogram, showing bilateral enlargement of both kidneys, elongated pelves, and marked distortion due to compression by the cysts.

Urine from the left side showed pus clumps, many white and red blood corpuscles, epithelial cells. Albumin was one plus. *Escherichia coli* were present.

Subsequent cystoscopic studies showed many pus and red blood cells, and also epithelial cells from both sides and finely granular casts.

On December 14, 1935, an intravenous pyelogram showed the kidneys enlarged. Delayed excretion of dye, incomplete filling of the pelvis and calyces in both sides were noted. A retrograde pyelogram showed elongation and flattening of the calyces and pelvis. Against these structures were seen rounded defects, the classical appearance of polycystic kidney disease.

Result of the Kahn test was two plus. Creatinine was 1.4 mg., urea 11.4 mg., and sugar 79 mg. A blood count taken on January 9, 1935 showed red blood cells 2,370,000, and hemoglobin 55 per cent.

**Autopsy Findings.** The liver edges were rounded and the organ enlarged, weighing 2,280 Gm.; its capsule was thin and smooth. Section of the parenchyma revealed a mosaic showing dark centers surrounded by thin rings of lighter colored parenchyma. These apparently marked out the hepatic lobules. The

uterus was normal in size, and had two pedunculated fibrous tumor masses attached to fundus. The left ovary had a small cyst filled with semi-solid hemorrhagic material. The kidneys were imbedded in scant perirenal fat. They were enlarged to a combined weight of 1100 Gm. The architectural structure of the kidney was so changed that it consisted almost entirely of thin walled cysts containing fluid of various colors ranging from straw to reddish brown. A cut section of the kidney revealed complete loss of normal architecture with replacement of most of the parenchyma by cysts similar to those seen on surface. The pelves were compressed by neighboring cysts. The ureters were normal. The adrenals were elongated and narrow, apparently due to pressure of the kidneys.

**CASE II.** J. W., 28 years old, colored, was admitted July 11, 1933 with a chief complaint of pain in the right side for the previous two to three years. He had had pain in the right side, from behind forward, from the region of the right kidney down to the right lower quadrant. Some pains in the left side had developed in the last year. In June, 1933 acute pains in the right side had been associated with nausea and vomiting. Hematuria, polyuria, nocturia and dysuria were also reported. The patient had lues and gonorrhea.

Masses were noted in the right and left upper quadrants, moving with respiration, ballotable and tender, extending from the costal edge to the umbilicus on the right side. Right costal vertebral tenderness was present.

Phenolsulfonephthalein excretion was 20 per cent the first hour, 40 per cent the second hour. The red blood cells numbered 3,700,000; hemoglobin was 75 per cent; the white blood cells were 9,100, with polymorphonuclears 74 per cent, and lymphocyte 26 per cent.

At cystoscopy, 2 ounces of blood were obtained in urine from the bladder. Moderate trigonitis was present. Both ureteral orifices and the bladder mucosa were normal. Blood was seen from the right ureteral orifice. The catheter passed up both pelves, there was no retention, and slight bloody urine was obtained from both sides. Few leucocytes and epithelia were present in urine from the left kidney, few leucocytes and many epithelia on the right. There were 15 red blood cells per high power field, a few white blood cells, and occasional lymphocytes. Albumin was one plus.

The temperature was 99°F., the blood pressure 160/120. The blood Kahn was three plus. Blood chemistry: creatinine 1.2 mg. per cent; urea nitrogen 9.7; sugar 95.

72 per cent, transitionals 3 per cent; lymphocytes 25 per cent; red blood cells 3,900,000, hemoglobin 70 per cent.

The patient was too ill for intravenous or

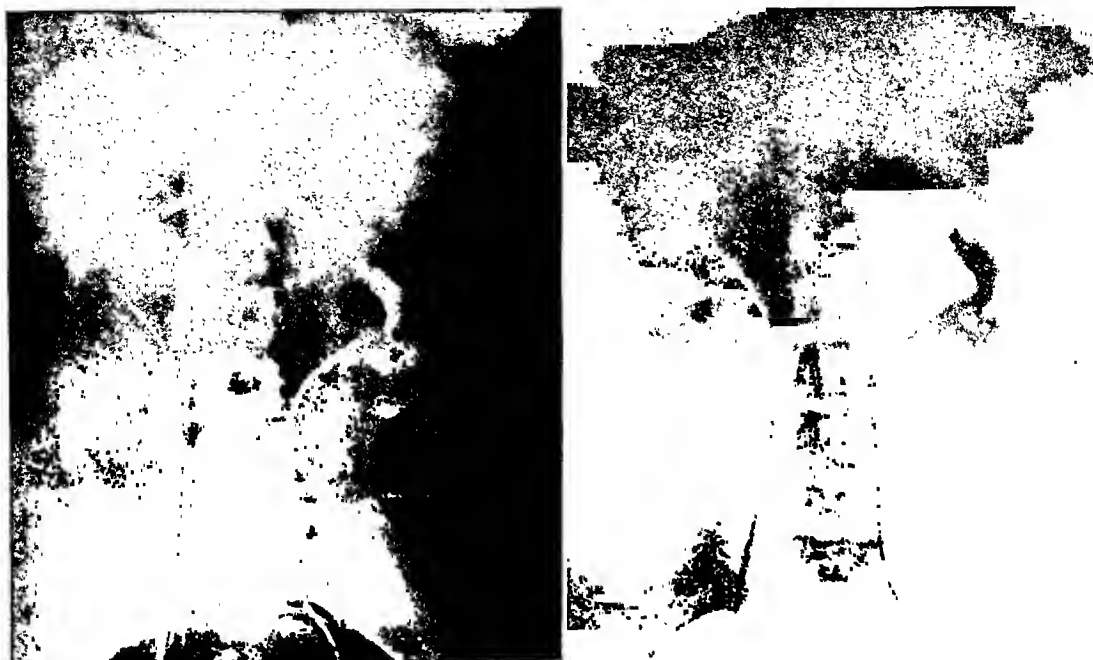


FIG. 2. Pyelogram, showing enlargement of both kidneys and elongation of both pelves and narrowing of pelvis due to compression by the cysts.

X-ray report of the urinary tract showed no evidence of stone. The right kidney appeared very much enlarged, while the left was not clearly defined. A retrograde pyelogram showed marked distortion and elongation of the right pelvis. On the left side, the pelvis was compressed from all sides. A diagnosis of polycystic kidney was made.

CASE III. M. K., 44, white, was admitted on February 16, 1935 with a diagnosis of polycystic kidneys, congenital essential hypertension, and right hemiparesis. The chief complaint was weakness of the right arm and leg of two days' duration. No dizziness and no unconsciousness had occurred.

Bilateral polycystic masses were felt in both upper quadrants. The patient had a midline scar of some previous operation.

X-ray examination of the urinary tract showed enlargement of the kidneys, especially of the left. The bilateral enlargement confirmed the clinical diagnosis of polycystic kidney disease.

The Kahn test was reported negative. Creatinine was 6.0; urea 45.8; sugar 89.0. A blood count taken on February 16, showed: white blood cells 8,070, with polymorphonuclears

retrograde pyelography and was discharged to a convalescent home on March 12, 1935.

CASE IV. E. D., age 32 years, colored, was admitted on November 1, 1935 with a complaint of hematuria. Painless hematuria had begun four years before, but cleared up spontaneously after several weeks rest in bed. In August, 1935, backaches, abdominal pains and hematuria occurred, but cleared up in a short time. The onset of the present attack began with a pelvic inflammation, bilateral pains in the kidney region with hematuria which persisted for three weeks. The patient had lost weight during the preceding few months. He denied cough, fever or night sweats. The abdominal pains had disappeared and the only symptoms remaining were hematuria, urgency and frequency.

The abdomen was soft, no masses were felt, but there was tenderness in both kidney regions. The temperature was normal.

The urine was bloody, with a specific gravity of 1.010 and one plus albumin. Microscopic examination showed many red blood cells and occasional white blood cells. The blood count was: red cells 3,600,000, hemoglobin 60 per

cent; leucocytes 10,000, polynuclears 72 per cent, lymphocytes 28 per cent.

Cystoscopy showed the bladder mucosa pale

Moderate ascites and tenderness were present over the entire left abdomen, a mass was palpable on the left, filling the abdomen from



FIG. 3. Case v. Gross enlargement of both kidneys. Many cysts of various sizes. Patient was too ill for pyelogram.

throughout, with small free blood clots floating about, and both ureteral orifices normal. There were no ulcers in bladder. A No. 6 catheter passed easily on the right; on the left side it was obstructed at 9 cm., but by manipulation passed up all the way to the pelvis. Urine from the right side was clear, from the left bloody.

Indigo carmine appeared on the right side in five minutes; on the left a faint color appeared in eight minutes.

A pyelogram showed moderate dilatation of the pelvis and calyces. There was a suggestion of multiple compression defects on both sides. Together with the history of recent hemorrhage and clear, pale urine these findings were suggestive of polycystic kidney. No acid-fast organisms were found.

**CASE V.** A. L., age 44 years, white, was admitted on September 26, 1933 with a complaint of hematuria and pains in both flanks. Four days prior to admission the patient had noted spontaneous, painless bleeding through the urethra and the need for frequent micturition. On September 24 nausea and cold sweats occurred and later the patient vomited and had pains in the left, lower quadrant. Insomnia and restlessness were present. A renal calculus had been passed twenty years before and gonorrhea had been contracted three years before.

the costal margin to three to four fingers below the umbilicus. The masses were hard, tender, irregular, nodular and not movable. There was left costal vertebral tenderness; the right side of the abdomen was normal.

Blood chemistry showed creatinine 13.9 mg. per cent, urea 116.2, sugar 125. The Kahn was negative. Blood pressure was 160/100, temperature before operation 102°F. and later 104. The white blood cells were 25,000, with polynuclears 88 per cent. Hemoglobin was 65 per cent.

Cystoscopy produced bloody urine from the left side, clear on the right. Indigo carmine appeared late and in poor concentration from both sides.

Operation was done on September 26, 1933 with the idea that a perinephric abscess was present. A left flank incision exposed a large polycystic kidney. Puncture of the cyst caused purulent and sanguinous fluid to exude. A drain was inserted.

At autopsy the pericardium contained about 10 c.c. of straw colored serous fluid. The heart was of average size. The musculature of the left ventricle showed thickening. The aorta and coronaries showed some fatty deposition.

Where the abdomen was opened, there was a small amount of hemorrhagic fluid in the lateral



gutters. The spleen was of average size, its borders well defined. There was a large lobulation which extended into the organ of about  $\frac{3}{4}$  inch. On section, the cut surfaces were darkened. The liver was of average size, its capsule smooth. The quadrate lobe presented small cysts of various sizes from a pinhead to a pea. The kidneys presented two large masses much greater than average. On the left there was marked extravasation of blood into the perirenal tissue. The surface of the kidney consisted of a series of cysts of various sizes and colors, sized from a pea to a marble. The right kidney presented a similar appearance. The left ureter was dilated.

The autopsy diagnosis was uremia; bilateral polycystic kidney; atherosclerosis; cystic liver.

#### COMMENT

Treatment recommended is operation, puncture of cysts, and decapsulation. Nephrectomy should never be done except possibly in cases of persistent suppuration in which other surgical measures have failed and in which death may result from continued infection.

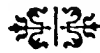
Medical treatment is that given in any chronic nephropathy, including rest, avoidance of physical or mental stress, or exposure to infection and dietetic regulations to prevent any overloading or irritation of the diseased kidney. When pyelitis or

pyelonephritis complicates the condition, catheter drainage and pelvic lavage with a weak solution of silver nitrate may be tried. Calculus complications may require surgical interference, if a stone blocks the ureter or the pyleureteral junction and conservative cystoscopic measures have failed. Surgery should not be done in other stone cases.

I wish to thank Dr. Solomon Weintraub, pathologist and Dr. William Snow, roentgenologist, for their respective opinions.

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# CASE REPORTS

## HETEROTOPIC GASTRIC MUCOSA AND REDUPLICATIONS OF THE INTESTINAL TRACT\*

ARTHUR R. KIMPTON, M.D.

AND

D. REYNOLDS CRANE, M.D.

Surgeon-in-Chief, First Surgical Service, Boston City Hospital

Assistant Pathologist, Mallory Institute of Pathology, Boston City Hospital

BOSTON, MASSACHUSETTS

WHILE the occurrence of gastric mucosa in ectopic foci throughout the body may be responsible for severe clinical signs and symptoms and may even lead directly to the death of the patient, it is also true that proper surgical treatment may produce a complete cure. In view of these facts we should like to call attention to the occurrence of this type of congenital abnormality in various portions of the gastrointestinal tract and related structures and report three unusual cases which nevertheless illustrate well its more common pathologic effects.

The presence of islands of gastric mucosa in the esophagus and in remnants of the vitelline duct (Meckel's diverticulum) is common. Nicholson<sup>1</sup> states that there is an incidence as high as 75 per cent in the upper portion of the esophagus. In a report of thirty-two cases of Meckel's diverticulum, Hudson and Koplik<sup>2</sup> found gastric mucosa in 52 per cent. This corresponds very closely with the figures from the surgical and autopsy records of the Mallory Institute of Pathology where, of the last twenty Meckel's diverticula examined histologically, ten, or 50 per cent, showed islands of ectopic gastric mucosa. Aside from these two locations the occurrence of ectopic gastric mucosa is extremely rare. It has, however, been reported in the duodenum by Taylor,<sup>3</sup> in the jejunum by Barták<sup>4</sup> and by Kimpton and Crane,<sup>5</sup> in the ileum by Poindecker<sup>6</sup> and by Taylor,<sup>3</sup>

and in the pancreas, gall-bladder and colon by Nicholson.<sup>1</sup> Its occurrence in the umbilicus in remnants of the vitelline duct has been described by Stone<sup>7</sup> and by Nicholson.<sup>8</sup>

Islands of ectopic gastric mucosa produce no typical or pathognomonic clinical signs or symptoms, these depending to a large extent upon the site of their occurrence. However, the one sign which they may have in common, regardless of their location, is hemorrhage into the gastrointestinal tract. The cause of the bleeding is the frequent presence of typical peptic ulcers either adjacent to or involving the ectopic mucosa, with ulceration of blood vessels which may actually lead to death from exsanguination. The importance of ulceration and hemorrhage in connection with Meckel's diverticula has been emphasized by previous writers<sup>2,9,10</sup> and Hudson<sup>11</sup> states that 31 per cent of Meckel's diverticula may show hemorrhage on this basis. In considering the various possible causes of intestinal hemorrhage this condition should be remembered, particularly when dealing with intestinal hemorrhage in children. The ulcerations associated with this anomaly may also lead to perforation with peritonitis or mediastinitis. The heterotopic mucosa may be of sufficient size or may proliferate to sufficient size to produce the clinical picture of a tumor with a palpable mass, obstruction, volvulus or intussuscep-

\* From the First Surgical Service and the Mallory Institute of Pathology, Boston City Hospital.

tion. The following three unusual cases will serve to illustrate some of these possible dangers of heterotopic gastric mucosa.

laxative; this was invariably followed by a watery defecation, but at no time were the stools abnormally dark or bloody. The attacks

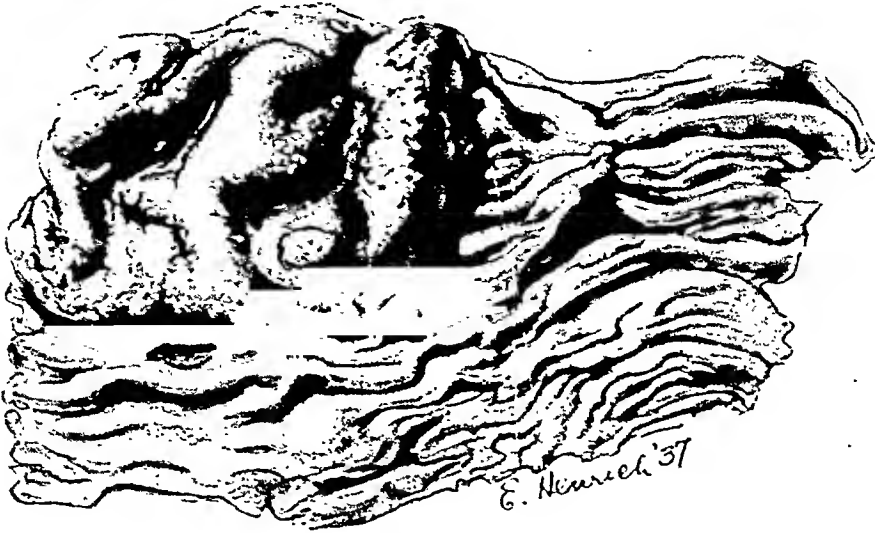


FIG. 1. Case 1. Gross specimen showing tumor nodule in jejunum. The gross resemblance of the mucosal surface of the tumor nodule to gastric mucosa is striking. About two times actual size.

#### CASE REPORTS

**CASE 1.** J. B., a 7 year old girl, was seen in consultation by one of us (A. R. K.) because of recurrent attacks of severe paraumbilical pain associated with nausea and vomiting since the age of 3. She was born at full term after a normal pregnancy, the fifth child of a family of nine. Her weight at birth was  $8\frac{3}{4}$  pounds and no physical abnormalities were noted. Her parents and siblings were entirely normal, and there were no pertinent factors in her past history other than those associated with her present illness.

The first abdominal complaint occurred at the age of 3 and was manifested by severe pain about the umbilicus, not localized, and marked by a continuous ache with occasional attacks of excruciating pain causing her to cry out. After two or three hours the child vomited and the pain was relieved. Similar attacks occurred subsequently three to six times a year. They lasted from one to three days, and began during the night as frequently as during the day. Following each attack the child appeared perfectly normal except for a sense of weakness. Fever never developed during any of the attacks. The mother always gave the child a

gradually became more frequent and severe, but no definite inducing factor was ever noted. Two years after the onset of this condition a physician was consulted for the first time and a diagnosis of intestinal worms was made. Three weeks later a second physician was consulted and for the first time an abdominal mass was palpated; the mother stated that a mass could be seen especially when the pain was severe. At this time a diagnosis of volvulus was made, the abdomen was tightly strapped with tape, and abdominal massage and shaking the child in an upside-down position by holding the feet were advised. Following this the attacks were much less frequent. One year later, because of a severe attack, the patient was referred to a hospital, where x-rays of the intestinal tract revealed nothing abnormal. During the year preceding the present examination she had had attacks of varying severity every four or five weeks. She was seen in consultation on June 21, 1937, having just suffered an acute attack of abdominal pain.

Physical examination was negative save for the abdomen, where an elongated tumor could be felt extending diagonally across the abdomen from left to right. It was 10 or 12 cm. in length, 2 or 3 cm. in width, soft, smooth and non-

tender. The center of the mass lay just beneath the umbilicus. The appearance was quite typical of intussusception. While lying quietly

measuring 7 by 5 by 0.4 cm. The serosa was negative but the entire wall was thickened and edematous, although not otherwise remarkable.

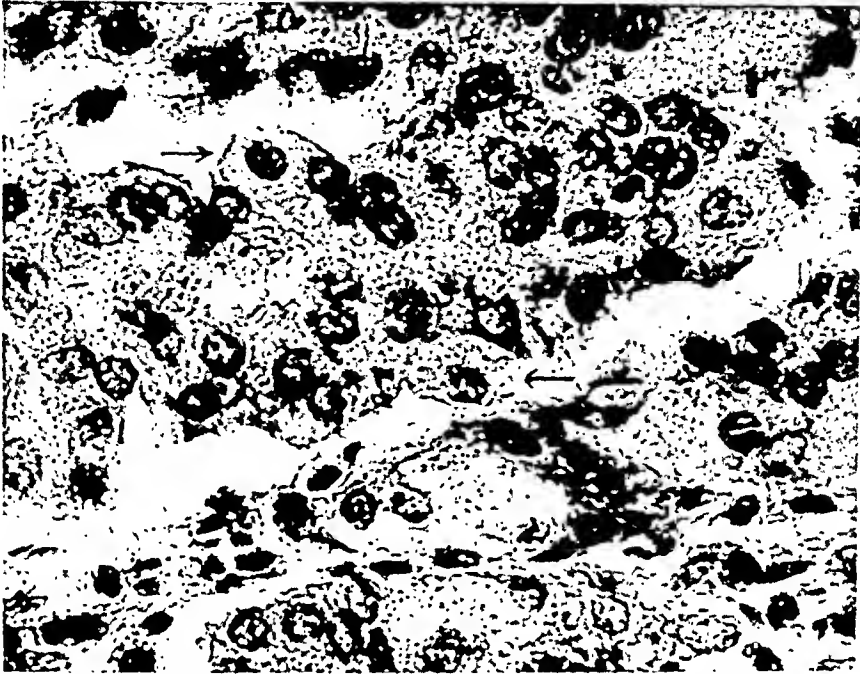


FIG. 2. Case 1. High-power field of the tumor mucosal cells, showing large, round parietal cells (indicated by arrows). Hematoxylin and eosin.  $\times 910$ .

on the examining table, the child suddenly screamed, doubled up, holding her abdomen, became pallid and perspired profusely. This lasted for about ten minutes and was followed in a few minutes by a similar attack. The abdominal tumor became very prominent through the child's thin abdominal wall while the pain was most severe.

At operation, the abdomen was exposed by a left paraumbilical midrectus incision and a large intussusception of the jejunum was found starting about 15 cm. below the ligament of Treitz. The bowel was edematous but entirely viable, and the intussusception was reduced with ease. When it was completely reduced, a soft, dough-like tumor mass was found filling the entire lumen of the jejunum 20 cm. below the ligament of Treitz. This was resected without difficulty by removing 12 cm. of jejunum, and a side-to-side anastomosis was done. The abdomen was closed in layers without drainage.

The immediate postoperative course was uneventful. Eighteen months after the operation the child was healthy and had had no recurrence of her previous symptoms.

**Pathologic Report.** The gross specimen consisted of a piece of small intestine (jejunum)

The mucosa in one area measuring 3 cm. in diameter was redundant, being elevated 0.4 cm. above the surrounding tissue to form a definite tumor nodule with a broad base. There was no evidence of infiltration of the underlying tissues.

Histologic sections through the redundant portion of mucosa showed it to be composed of long mucous glands of the gastric type in some of which numerous large, round, eosinophilic parietal cells could be readily identified. At the margin of the nodule there was an abrupt transition to a mucosa of the jejunal type, with many large plicae circulares and numerous goblet cells. The tumor nodule itself lay entirely on the mucosal side of the muscularis mucosa, and the redundancy of the mucosa noted in gross examination was due to the numerous gastric glands of which the tumor was composed. There were occasional mitotic figures in the epithelium, but the cells were perfectly differentiated into adult chief and parietal cells, as found in the mucosa of the stomach. The submucosa, muscularis and serosa were normal save for evident intercellular edema.

This case is essentially a typical one of intussusception, but is unusual and of interest because of the embryologic anom-

hospital after his birth that he vomited frequently, but his parents never returned him to the hospital for study as advised. There were

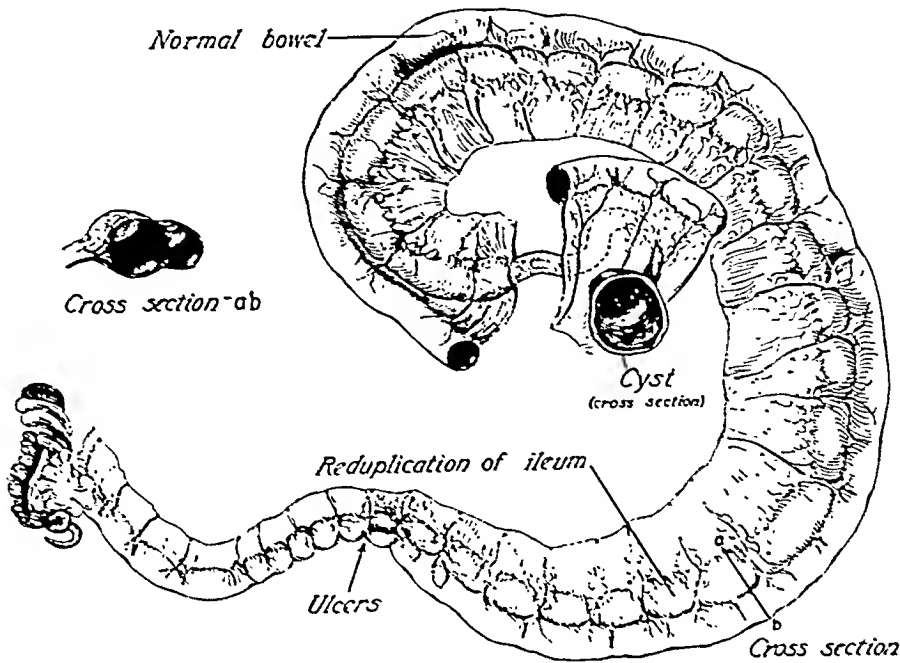


FIG. 3. Case 11. Drawing to demonstrate the abnormality of reduplication of the ileum. Cecum and appendix are on left.

aly which was responsible for the intussusception. The rôle of tumors in the production of intussusception, particularly in the adult, has been emphasized by recent investigators,<sup>12,13,14</sup> although the association of the two lesions has long been recognized. Roan,<sup>13</sup> in reporting a series of cases of intussusception, states that tumors are a negligible factor in children up to the age of 3. Since benign tumors are much commoner than malignant ones in the small intestine, they predominate in any analysis of tumors causing intussusception. Nevertheless, the polypoid nature of many benign intestinal neoplasms renders them even more potent factors in the general etiology of intussusception. In all reported series the commonest types of tumors encountered are myomas and adenomas, although instances of fibroma, lipoma, hemangioma and other benign tumors are not infrequent.

CASE 11. C. C., a 9 months old baby boy, was admitted to the Boston City Hospital because of bleeding by rectum. He was the first child of a 28 year old white housewife and was born at term. It was noted in the

no other pertinent factors in his past history other than those associated with his present illness.

The first appearance of rectal bleeding occurred at the age of 3 months about three weeks after the onset of pertussis. At that time the child had three red to tarry stools. He was admitted to the South Department of the Boston City Hospital because of the pertussis and rectal bleeding, but was taken home against advice before he could be properly studied. There had been no recurrences of the rectal bleeding up until the day of the last admission when his mother noted the presence of black tarry stools and fresh blood in his diapers twice within a period of two hours.

The physical examination showed marked pallor of the skin, a hard round mass about the size of a lemon in the left upper quadrant of the abdomen, distention of the abdomen and the presence of blood in the rectum. In addition he showed some beading of the ribs and enlargement of the head with prominent frontal bosses. The physical examination was otherwise negative. The only laboratory data gathered were a hemoglobin of 25 per cent, a red blood count of 2,060,000, and a white blood count of 17,200 with 80 per cent polynuclear cells.

A laparotomy was performed and a giant diverticulum of the ileum was found. The ileum became double-barreled at a point about



FIG. 4. Case II. Cyst after cross section showing the rugose gastric-like appearance of the lining and a typical "punched-out" peptic ulcer. About actual size.

25 cm. from the ileocecal valve. This double ileum continued proximally for about 95 cm., the inner or false bowel lying in the mesentery of the outer or true bowel but in close approximation to it. The false segment then dipped towards the base of the mesentery penetrated the mesentery and ended in a round cystic structure about 6 cm. in diameter, apparently corresponding to the mass noted clinically in the left upper quadrant of the abdomen. It was felt that the cyst and an ulcer which could be palpated at the bifurcation of the ileum were the main sources of the bleeding and therefore the cyst, about 5 cm. of the diverticulum with the cyst and about 5 cm. of ileum at the point of bifurcation were resected. A side-to-side anastomosis was then done between the terminal ileum and a portion of ileum overlying the diverticulum.

**Pathologic Report.** The gross specimen consisted of three parts. The first was a piece of intestine from the bifurcation of the ileum 5 by 4.2 by 0.3 cm., the surface of which was gray-red and edematous. In the middle of the mucosal surface of this fragment were three punched-out ulcers, the largest 1 cm. in diameter and 0.3 cm. in depth, the others being but

slightly smaller. The other two portions of the specimen were a piece of intestine measuring 5 by 1 by 0.3 cm. and somewhat resembling an appendix and a cystic structure 6 cm. in diameter filled with partially digested black blood and showing a rugose gastric-like mucosa. It contained approximately eight punched-out ulcers, the largest measuring 1 by 1 by 0.6 cm.

Histologically all three of these segments showed typical gastric mucosa with both chief and oxyntic cells the latter being extremely abundant. The muscle layers of the segments were those of small bowel save for that of the cyst which showed interlacing muscle bundles similar to those seen in the normal stomach. The ulcers were sharply defined, in some areas extended deeply into the muscularis and showed a moderate focal lymphocytic reaction.

Following the operation the patient showed progressive elevation of temperature and pulse and died within twenty-four hours.

The only important autopsy findings were those related to the intestinal tract. The large bowel was not remarkable, and 23 cm. proximal to the ileocecal valve there was a side-to-side anastomosis between two closed and sutured ends of ileum. The ileum proximal to the anastomosis was double, being composed of two distinct tubes which were inseparably fused at their adjacent surfaces. The inner intestinal tube was greatly distended as it lay in the mesentery of the outer or normal ileum. The mesenteric vessels to the true bowel circumscribed this inner bowel. These intestinal tubes ran parallel for a distance of 90 cm. at which point the inner tube became detached and ran for a short distance towards the base of the mesentery. The outer intestine continued on proximally to join a normal jejunum, duodenum and stomach.

Histologic sections showed this inner segment of bowel to be lined throughout by gastric mucosa with numerous oxyntic cells. The muscularis was incomplete, being entirely lacking in the portion where the two tubes were adjacent although the remainder of the muscularis of each segment was normal.

**CASE III.** F. W., a 77 year old white male, was admitted to Boston City Hospital because of edema and dyspnea of increasing severity. Because of his poor condition no reliable history was obtained. On physical examination he showed an enlarged heart, blood pressure of 140/90 and marked dependent edema. Labora-

tory data were not significant. The patient did well for a few days and then showed increasing signs of cardiac failure and died twenty days after admission.

portions of this diverticulum connecting directly with the bowel lumen. It would seem that autodigestion by the local concentration of hydrochloric acid in the sac

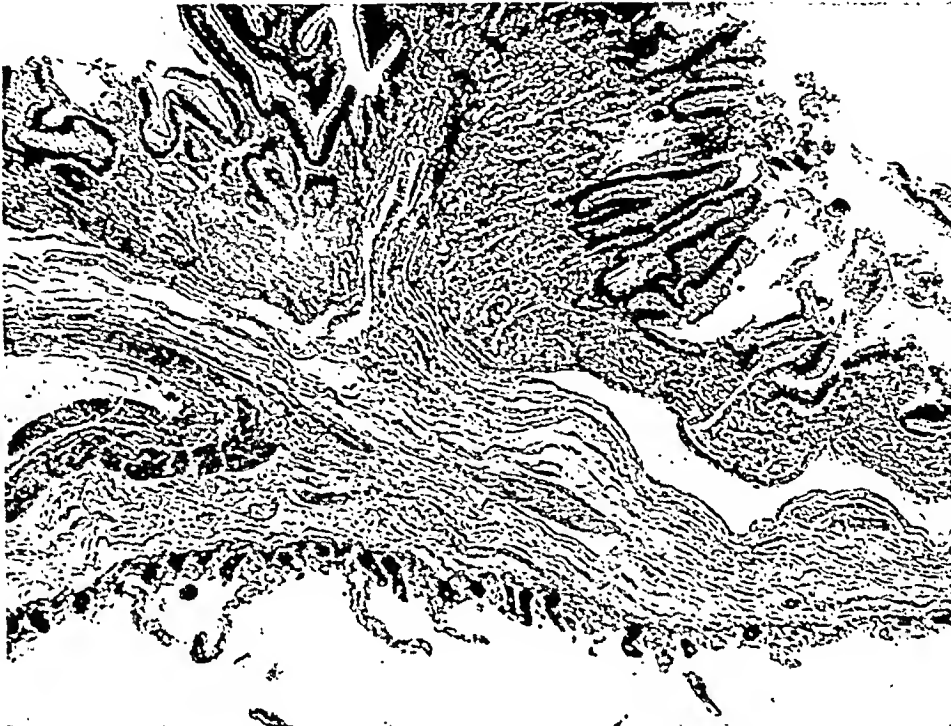


FIG. 5. Case 11. Cross section through normal bowel and reduplication at point indicated in Figure 3. Gastric mucosa lining reduplication above; lumen of true bowel with normal mucosa below. Note the absence of the muscularis between the two lumens on the right of the photograph. Hematoxylin and eosin.  $\times 30$ .

Autopsy showed ulceration in the esophagus about 4 cm. from the cardia and measuring about 3 cm. in diameter, with an irregular edge and a green sloughing base extending into the wall for about 0.2 cm. In addition signs of cardiac decompensation and a bilateral bronchopneumonia were apparent.

Histologically at the margin of the ulcer a few glands similar to those of the stomach could be identified. These glands showed only chief cells, however, no oxyntic cells being seen. At the base of the ulcer there was complete destruction and fibrous replacement of the normal muscularis of the esophagus, and in addition there was a marked chronic inflammatory reaction throughout the wall of the ulcer with a moderate diffuse lymphocytic and plasma cell infiltration.

These two cases serve to show the association of ulcer and bleeding with ectopic gastric mucosa. The explanation of the symptomatology of Case 11 is clear enough since there were bleeding ulcers in various

and at the opening of the diverticulum may have been a most important factor in the development of the ulcers. It is unfortunate that a more pertinent history was not available in the third case, but Lyall<sup>15</sup> states that the common clinical symptoms of ulcer of the esophagus are pain, dysphagia and hematemesis. In regard to peptic ulcers of the esophagus Jackson<sup>16</sup> lists the following causes: focal infection, retrograde flow of gastric juice, cardiospasm, insufficiency of the cardia, insufficiency of the diaphragmatic pinch-cock, and ectopic gastric mucosa. He points out that the occurrence of gastric mucosa in the esophagus may be an active factor by the secretion of gastric juice or passively by supplying a tissue that may be sensitive to concentrated gastric juice. The role of ectopic gastric mucosa in this type of ulcer of the esophagus is also emphasized by Lyall and by Hurst<sup>17</sup> who feel the most

important factor is the active secretion of hydrochloric acid by the ectopic tissue and the trapping of this acid in the lower

in various ways. This, however, carries us no closer to the pathogenesis of such lesions, beyond removing the necessity of explain-

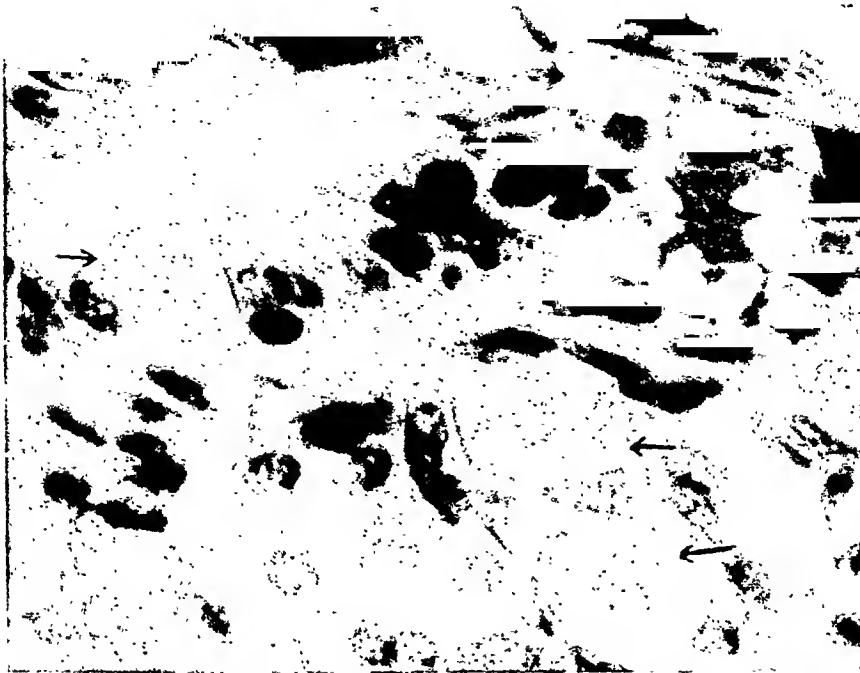


FIG. 6. Case 11. High lower field of gastric mucosa shown in Figure 5. Note the large round parietal cells. Hematoxylin and eosin.  $\times 1200$ .

portion of the esophagus by cardiospasm. The commonest complications of peptic ulcer of the esophagus are perforation and hemorrhage. The extensive damage evident in Case III shows how such ulcers may well go on to perforation and mediastinitis.

#### ETIOLOGY

The reasons for the development or existence of ectopic gastric mucosa are entirely unknown although numerous theories have been suggested. We agree with Nicholson<sup>1,8</sup> who concludes that the developmental heteromorphoses indicate that the original prospective potencies of cells are wider than their prospective values; and that the accidental heteromorphoses suggest that the original prospective potencies are not entirely lost during development, since they are sometimes accidentally revealed in pathologic states in old age. In other words, one must bear in mind the common origin of the intestinal epithelium and realize that each cell may differentiate

ing all such findings on the basis of embryologic rests. Curd<sup>18</sup> reviews the various theories of origin and development of ectopic gastric mucosa. Briefly stated, these are:

1. The presence of a substance in the intestines which stimulates the formation of intestinal mucosa, and the lack of which is necessary for the formation of gastric mucosa. This substance was thought to be bile.

2. An inflammatory process in the endoderm during some stage of embryologic development.

3. Misplaced fetal inclusions or rests.

4. The rapid growth of the intestines does not allow the differentiation of cells into the gastric type, while the smaller size and slower growth of the stomach allow for complete differentiation of the gastric mucosa.

The first theory has been proved incorrect and is further disproved by the first case reported here. The theory of rapid



development of the intestines is ruled out by our second case. It is impossible to conclude what mechanism governs the

6. The nodules of Lewis and Thyng.<sup>20</sup> These authors noted nodules of epithelial cells occurring along the course of the

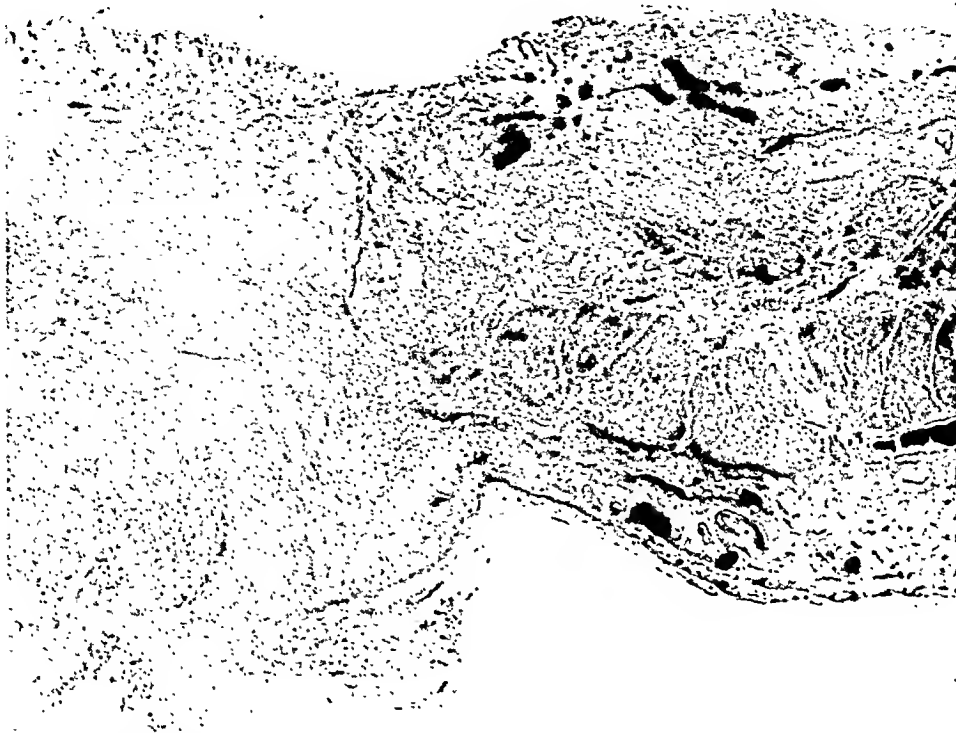


FIG. 7. Case III. Section of esophageal ulcer showing extensive scarring and complete destruction of the muscularis and marked chronic inflammatory reaction extending through to the adventitia. Mucosal surface is above. Hematoxylin and eosin. X 15.

development of ectopic gastric mucosa in the light of our present knowledge.

Case 11 showed an unusual deformity in addition to the ectopic gastric mucosa. Hudson collected eighteen such cases from the literature and reported three of his own under the title of "Giant Diverticula or Reduplications of the Intestinal Tract." The pathogenesis of this type of anomaly is likewise entirely unknown. Hudson<sup>19</sup> lists the following theories:

1. Atavism or reversion to an earlier phylogenetic form.
2. Twinning, in which case "the stimulation to reduplication, although acting at an early stage of cell division has affected a certain section only of the embryo."
3. Through the development of a median septum.
4. Sequestration of a segment of the intestinal tube.
5. Persistence and alterations of the vitelline duct.

gastrointestinal tract in pig, rabbit and human embryos. Normally these disappear or coalesce to form a part of the lumen of the digestive tube but they may persist.

The evidence is not conclusive for any single theory, but Hudson concludes that the evidence favors the belief that the nodules of Lewis and Thyng<sup>20</sup> are antecedents of those cysts and diverticula not associated with remnants of the omphalomesenteric duct.

#### TREATMENT

The only satisfactory treatment of islands of heterotopic gastric mucosa regardless of the location or form of their occurrence is complete surgical removal where possible. Reduplications of the intestinal tract should also be completely excised since they may be wholly or partially lined with gastric mucosa. At this point we should also like to emphasize the importance of a thorough surgical explora-



tion in individuals, and especially children, presenting vague or unusual but persistent intestinal symptoms particularly when associated with gastrointestinal hemorrhage. In the case of the esophagus Jackson<sup>16</sup> recommends removal of foci of infection, cauterization of ulcers with weak silver nitrate and a dietetic régime such as would be advised for a patient with a gastric ulcer of the stomach with especial attention to the avoidance of rough, harsh and bulky foods.

## SUMMARY

1. Three instances of heterotopic gastric mucosa are reported (esophagus, jejunum and giant diverticulum of ileum), two of which were known to have been responsible for clinical symptoms.

2. The dangers of ulceration, hemorrhage and perforation have been emphasized in connection with ectopic gastric mucosa.

3. The theories of origin of heterotopic gastric mucosa and giant diverticula of the intestine are presented.

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# PURULENT PERICARDITIS\*

## REPORT OF A CASE WITH UNUSUAL COMPLICATIONS

JOHN P. MALEC, M.D.

AND

PETER A. MIDELFART, M.D.

Instructor in Surgery, University of Wisconsin  
Medical School

Midelfart Clinic

MADISON, WISCONSIN

EAU CLAIRE, WISCONSIN

**P**YOPERICARDIUM may occur as a serious complication of some concurrent disease, most often another suppurative process within the chest. The treatment is surgical and carries a mortality of about 50 per cent. Conservative treatment is of no value. This mortality rate is still higher when complicated by empyema, particularly of the left side. In view of these facts and the scarcity of reports in the literature we feel justified in presenting a case of streptococcus pneumonia with a left-sided empyema, purulent pericarditis, massive right pleural effusion, ascites, and thrombophlebitis of the right jugular vein.

N. V., a 16 year old white male, was admitted to the Wisconsin General Hospital on May 1, 1937, because of pain in the left chest. About three weeks prior to admission he had developed a "head cold," and on April 23, 1937, there had followed malaise, cough, dyspnea, and fever. A diagnosis of bilateral pneumonia had been made by his local physician. The symptoms slowly subsided, but the cough, at first non-productive, began to yield a thick, blood-streaked, odorless sputum. Fever continued in the neighborhood of 100°F. The night before admission an acute pain developed in the left chest, upper abdomen, and the shoulder of the same side and the fever rose to 105°F.

The patient was alert, dyspneic, coughing paroxysmally. There was a lag of the left hemithorax during respiration accompanied by a friction rub anteriorly, increased tactile fremitus, and dullness over the entire left chest as high as the second interspace anteriorly. Breath sounds were absent or greatly suppressed over the same area. A few crackling râles were present at the right base. The heart

rate was rapid (136 per minute) with an accentuation of the pulmonic second sound. To percussion the heart was of normal size and shape. A diagnosis of left upper lobar pneumonia with massive pleural effusion was made and confirmed by x-ray.

Laboratory findings: Hemoglobin 14.7 Gm. Red blood count 5,350,000; white blood count 33,500, with 96 per cent neutrophils. Non-protein nitrogen 23 mg. per cent. The sputum was negative for pneumococci types 1 to 4, but showed a hemolytic streptococcus. Serum protein was 6.1 Gm.

The patient's course was stormy and marked by a profound toxemia. A thoracentesis performed on the third day after admission revealed a slightly cloudy fluid which on culture also showed hemolytic streptococci. Therapeutic doses of oral and intramuscular sulfanilimide were accompanied by the rapid development of cyanosis and were discontinued before any beneficial effect could be ascertained. To relieve dyspnea and await the formation of a pyogenic pleural membrane, the empyema cavity was aspirated daily until it was impossible, by this method, to keep pace with the rapid pus formation. On May 19, intercostal drainage was instituted and the pleural cavity was decompressed slowly over a period of forty-eight hours. The respirations improved with closed drainage as did the general condition, until June 16, when there appeared a new symptom—substernal pain. Bedside chest films taken at this time showed a heart shadow somewhat larger than on previous examination, but because of the extensive pleural reaction and the fluid, as well as consolidation at the left base, it was felt that a diagnosis of pericardial effusion could not be made roentgenographically.

During the next fifteen days an attempt at pericardial tapping yielded nothing and the patient became progressively worse. On July 4

\* From the Thoracic Surgery Service, State of Wisconsin General Hospital, Madison, Wisconsin.

an acute circulatory collapse developed, characterized by extreme dyspnea, with cyanosis, profound shock and muffled rapid heart tones.

Further treatment consisted in the irrigation of the two sinuses, hot compresses to the neck, and frequent decompression of the right pleural

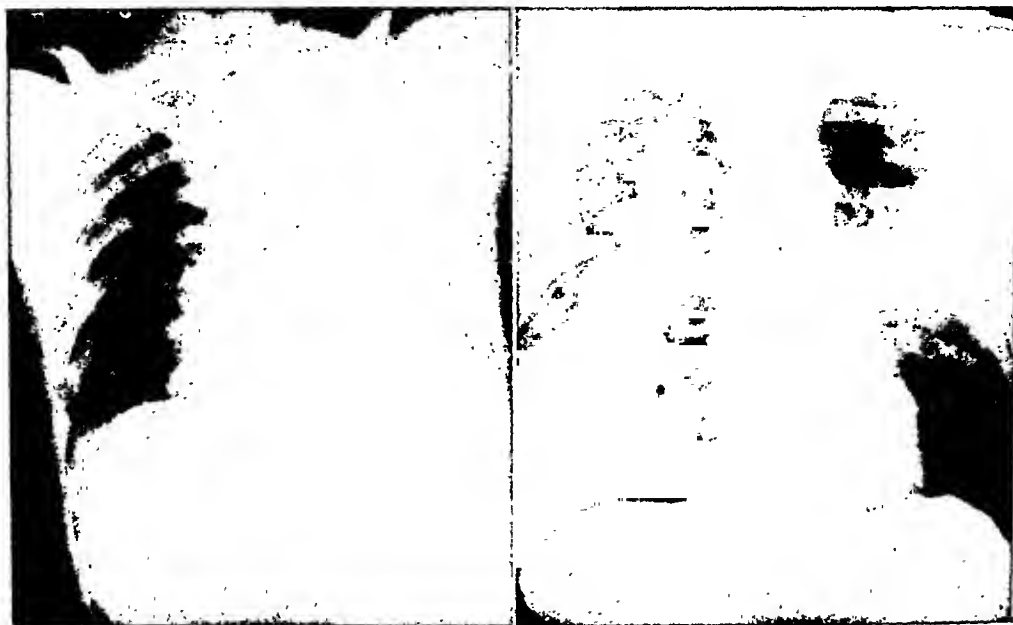


FIG. 1. A, pleural effusion entirely obscuring the left lung and pushing the heart slightly to the right. B, following an intercostal thoracotomy the haze over the left lung is less dense and the heart has returned to its normal position.

Pericardial tap was again considered advisable and yielded 100 c.c. of sanguinopurulent fluid. With the patient in extremis, pericardiotomy was performed under local anesthesia by sub-perichondral resection of the fourth and fifth left costal cartilages. As the sac was incised, pus under tension welled up. In all 950 c.c. was recovered. A 24 F. catheter was inserted. Improvement in breathing, color, and pulse was immediate. Cultures of this pus showed hemolytic streptococci.

As early as July 1, there were signs of fluid rapidly accumulating in the right chest. Every other day amounts ranging from 500 to 1600 c.c. of straw-colored, coagulable fluid were removed. By July 12 there was a massive collection of ascitic fluid in the abdomen and edema of the right neck with marked tenderness along the course of the internal jugular vein on that side. At this period both pericardial and left empyema sinuses were draining well but the question of possible pocketing in the former was raised. Numerous pericardial adhesions were found on gloved finger exploration and these were lysed with improvement in drainage.

cavity by thoracentesis. The ascites persisted for almost a month, but abdominal paracentesis was not deemed advisable as long as adequate vital capacity was maintained by right chest aspiration. Improvement was gradual but progressive, and both sinuses were closed at the time of discharge on September 11, 1937. Since dismissal the patient has remained well.

Electrocardiographic tracings in this case are interesting. The electrocardiogram taken July 20, sixteen days after pericardiotomy and while the pericardium was draining well, showed low voltage, slight depression of the S. T. segments in all the limb leads, and inversion of the T waves. By September 9, all drainage had ceased and a second electrocardiogram then showed an increase in the amplitude of the Q.R.S. complexes in all leads, almost isoelectric S.T. segments, persistence of inversion of T<sub>1</sub>, T<sub>2</sub> was tending to become positive, T<sub>3</sub> was definitely upright, and T<sub>4</sub> taken with the old technique<sup>10</sup> was upright. The last electrocardiogram taken almost a year after surgery showed still further increase in Q.R.S. amplitude especially in leads II and III, upright T

waves in leads I and II, diphasic T in lead III, and T<sub>4</sub> had become diphasic with the new technique.<sup>10</sup>

came the appearance of abdominal fluid which we feel could be only a transudate, although its identity was never proved.

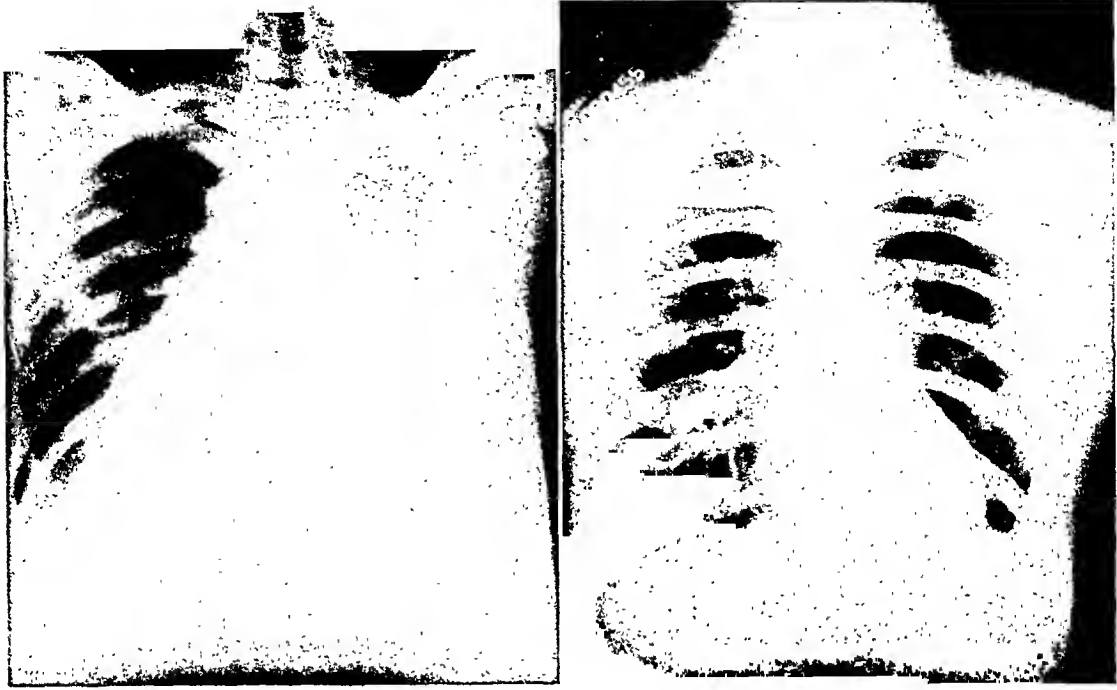


FIG. 2. A, the left lung field is obscured by a pleural effusion probably due to inadequate drainage of the empyema cavity. The cardiac shadow is definitely enlarged and of the "water bottle" type. B, June 10, 1938, following thoracotomy. Almost complete return to normal. Note obliteration of the left costophrenic sulcus.

Katz, Scott, and Feil<sup>1,2</sup> reported that in experimental distention of the pericardial sac there is a decrease in the Q.R.S. amplitude, elevation of the S.T. segment, and inversion of the T wave. Experiments of Bay, Gordon, and Adams<sup>3</sup> produced the same results except that the S.T. segments were occasionally depressed. In a later clinical article by Vander Veer and Norris<sup>4</sup> electrodiographic changes in fourteen cases of pericarditis were presented with inclusion of the chest lead. Six cases of this series showed elevation of the R.T. segment to be the most pronounced finding, and interestingly enough, the chest lead was normal.

For some of the following statements we have basic proof; the rest are only hypotheses. The right-sided pleural effusion was a sterile transudate which coagulated on standing and developed at a time when the right pulmonary fields were clear and mechanical stresses within the chest were greatest. Almost simultaneous with this

There are two explanations for these accumulations; namely, intrathoracic impediment to venous return or cardiac failure. The former seems most likely in a patient of this age without previous evidence of cardiac disease. Part of this is substantiated by the presence of venous obstruction in the right side of the neck accompanied by unilateral uniform swelling, marked tenderness, and a palpable thrombosis of the external jugular vein.

It is true that dependent edema of the lower extremities did exist, and this in the absence of a hypoproteinemia is explained on a basis of intra-abdominal pressure on the iliac vessels.

The former contention of the utter futility of drainage of pyopericardium because of the frequency of complication later by obliterative pericarditis has long been exploded. Shipley and Winslow<sup>5,6</sup> reported only two cases of adhesive pericarditis following drainage of a pyoperi-

cardium in an extensive review of the literature up to January 1, 1935. In our case there was evidence of adherence of the

muscle or the cardiac chambers. In a patient already taxed to the utmost by his disease, the latter trauma may be sufficient

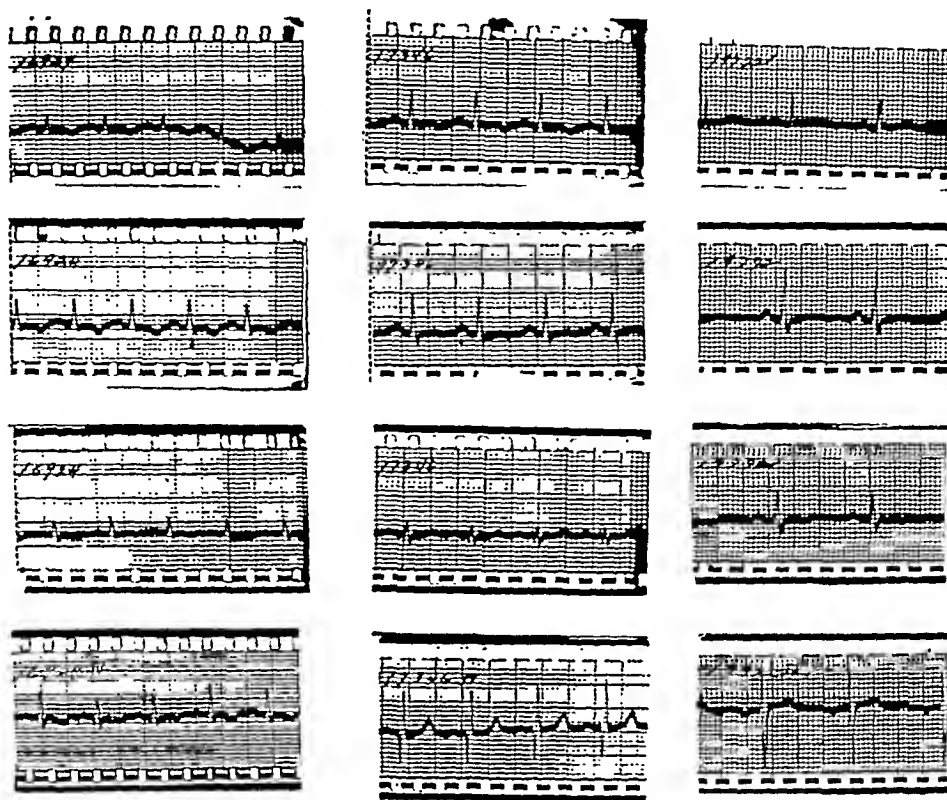


FIG. 3. Electrocardiograms. A, July 20, 1937; B, September 9, 1937; C, June 10, 1938.

pericardium to the operative scar one year after operation, but certainly no evidence of any degree of obliteration of the pericardial sac or decrease in the gross cardiac reserve. They<sup>5,6</sup> contend that purulent pericarditis is an abscess, similar to a collection of pus anywhere else, and should be similarly treated by adequate incision and drainage. As previously stated, operative treatment yields a mortality rate of 50 per cent, but anything short of this, including aspiration at periodic intervals, is uniformly fatal.

Most writers<sup>2,3</sup> feel that aspiration in purulent pericarditis should not be attempted; first, because a negative tap frequently occurs and leads to a false sense of security, and secondly, the needle is apt to be inserted directly into the heart

to cause death. The collection of pus is greatest behind and below the heart causing this organ to be in close proximity to the anterior pericardium and chest wall. In our own case a sanguineous fluid was obtained by aspiration, yet pericardiotomy performed immediately afterward revealed frank pus. On the other hand, aspiration in the case of serous pericarditis is fully as efficacious as pericardiotomy. Caughey<sup>7</sup> and Stewart<sup>8</sup> report satisfactory results with this procedure.

Pocketing of pus occurred behind the heart, giving the syndrome of obstruction to the vena cava. Re-exploration of the pericardial sac ten days after the pericardiotomy, breaking up adhesions and reestablishing drainage were sufficient to relieve this obstruction. Even with this

unfavorable circumstance, cure eventually resulted.

#### CONCLUSIONS

1. A case of streptococcal empyema complicated by a purulent pericarditis was successfully treated by drainage.

2. Early and adequate drainage of purulent pericarditis is the treatment of choice and rarely results in postoperative adhesive pericarditis.

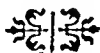
3. Aspiration of a purulent pericarditis may be both ineffectual and dangerous.

4. Evidence of pressure on the vena cava following pericardiotomy may indicate pocketing of pus behind the heart and re-exploration of the pericardial cavity is advisable.

5. Electrocardiographic tracings are an aid in arriving at a diagnosis of pericarditis with effusion. The changes to be noted are: elevation or depression of the S.T. segment, inversion of the T wave, and diminution of Q.R.S. amplitude. Changes occur in all four leads.

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# INTRAPLEURAL FOREIGN BODIES\*

JAY IRELAND, M.D.

Associate Attending Surgeon, Children's Hospital

CHICAGO, ILLINOIS

FOREIGN bodies in the bronchi and lungs are rather common but in the pleural cavity are comparatively rare. aspirated pus showed type 1 pneumococcus. On December 10, 1937 a right thoracotomy was performed under novocaine anesthesia and a

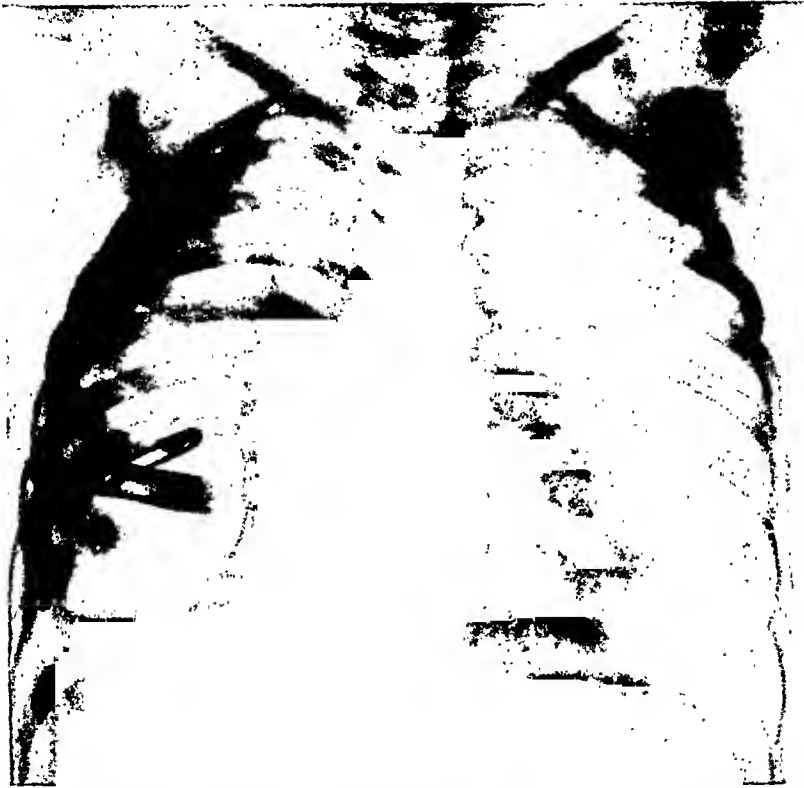


FIG. 1. Showing the empyema of the right chest with a rubber drainage tube extending into the empyema cavity. Just inferior to the drainage tube are two foreign bodies floating on the fluid surface.

The following case is of interest because of its difficult diagnosis and simplicity of treatment.

A boy, aged 4 years, entered the Children's Memorial Hospital November 16, 1937 with a diagnosis of early right lower lobe pneumonia. Twelve days after admittance the child developed a right sided empyema and was treated, on three occasions within the following nine days, by aspiration of pus. Cultures of the

rubber cylindrical tube inserted into the pleural cavity. The patient improved rapidly after this.

A roentgenogram of the chest taken January 17, 1938 (thirty-eight days after the thoracotomy), revealed three foreign bodies in the right pleural cavity at the costophrenic sinus. (Fig. 1.) In some of the roentgenograms taken later the bodies floated on top of the intrapleural fluid while in others they seemed to be at the bottom of the fluid. There were numerous suggestions as to what these foreign bodies

\* From the Surgical Service of Dr. A. H. Montgomery at the Children's Memorial Hospital. Read before the Chicago Surgical Society, December 9, 1938.

were. It was thought at first that they might be pieces of a drainage tube which had become old and broken. However, an investigation in

finally decided to attempt to wash them out by irrigation. The child was laid on his unin-  
volved side and normal saline irrigation through

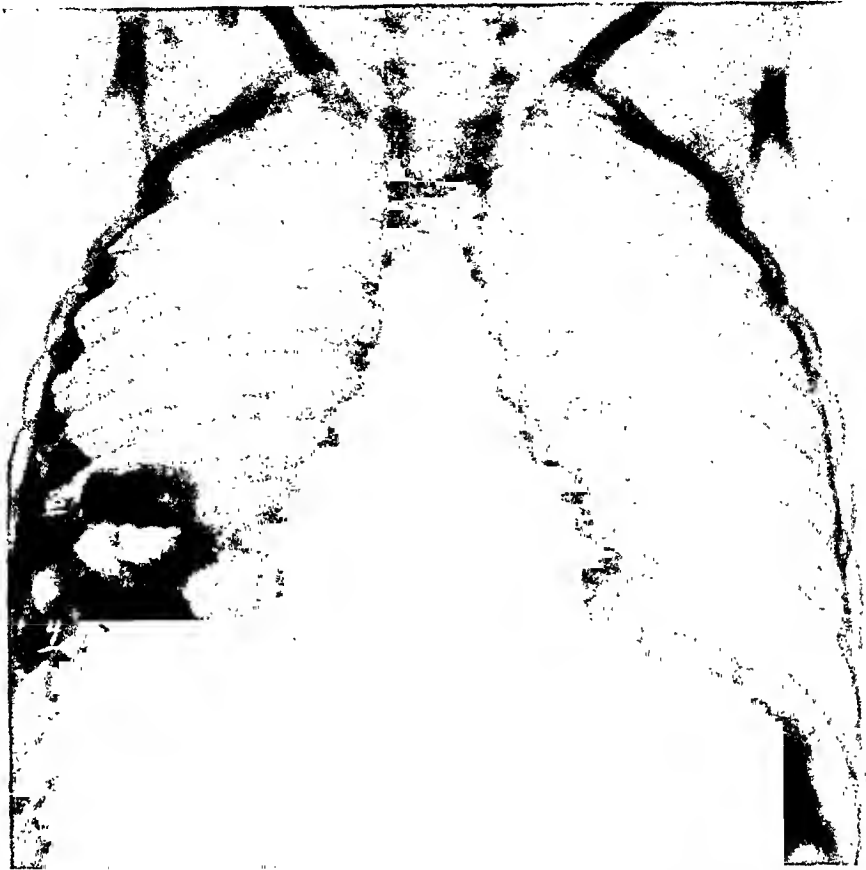


FIG. 2. The Arabic numerals 1, 2, 3 and 4 are opposite the oblong areas of zinc oxide ointment upon the skin of the posterior chest. These areas are 0.01, 0.25, 0.5 and 1 cm., respectively, in thickness.

the operating room where the tube was inserted and in the ward where it might have been removed and replaced, revealed the fact that only new rubber tubing was used in this case. Also upon testing a rubber drainage tube in water it was found that the tube floated on top of the water and as the foreign bodies found in this case were sometimes seen at the bottom of the fluid in the films it was hardly possible that they were due to retained bits of tubing. No history was given of the presence of any foreign body in the upper respiratory passages which might have penetrated the lung and visceral pleura.

It was decided to remove the foreign bodies regardless of their composition. The original thoracotomy opening was still present and it was believed that the bodies could perhaps be most easily removed through it, possibly by an endoscope of the type used in bronchoscopic procedures. However, since the bodies seemed to float in some of the roentgenograms it was

the thoracotomy wound was begun. A few seconds later the child gave a violent heaving cough and the irrigation fluid gushed from the wound carrying the foreign bodies out of the chest with it. They proved to be masses of zinc oxide ointment. Upon investigation it was found that this ointment had been applied to the skin around the drainage tube because of a dermatitis due to the pus escaping from the empyema. Roentgenograms taken after the irrigation showed the foreign bodies to be absent.

The zinc oxide ointment was not considered before the irrigation as a cause of the opaque bodies. In order to show experimentally whether zinc ointment would cast a shadow in a roentgenogram layers of zinc oxide ointment of various thickness were placed upon the chest wall externally and roentgenograms taken through the chest. Figure 2 shows such a roentgenogram with zinc oxide ointment applied posteriorly upon the skin of the chest.



The Arabic numerals 1, 2, 3, and 4 are opposite the ointment oblongs which are 0.01, 0.25, 0.5, and 1 cm. respectively in thickness. The oblong of 0.01 cm. thickness is not visible, but the three areas of greater thicknesses are readily seen.

The child made an uneventful recovery and was discharged from the dispensary May 9, 1938.

Very few reports of intrapleural foreign bodies were found in the literature. They may be classified as (1) those entering the pleural cavity after having been inhaled, passing through the lung; and (2) those passing through the chest wall from the exterior.

Davidsohn,<sup>1</sup> in 1931, was able to collect reports of ten cases in the first group and added one of his own. These foreign bodies included straw, grass, rye, barley and other grain ears, and artificial teeth. His case was that of a deciduous tooth found in the pleura at necropsy in a woman aged 33 years. As a deciduous tooth is seldom shed after 12 or 13 years of age, the tooth in Davidsohn's case was probably in the pleural cavity for at least twenty years.

Graham<sup>2</sup> reported a case in which a child aged 18 months aspirated a branch of a tree. Part of the branch was removed at a thoracotomy operation but the remainder was found intrapleurally at necropsy.

In the second group of cases, that of foreign bodies penetrating through the chest wall from the exterior, are those due to accidental penetrations of the chest wall, missiles from fire arms, and unfortunate occurrences from surgical operation.

Andrews<sup>3</sup> had six needles break in doing 58,680 chest punctures. In one of his cases and in one reported by Passual,<sup>4</sup> an intrapleural broken needle was successfully removed by a thoracoscope. Rubber drain-

age tubes which have not been sufficiently anchored have not infrequently been found in the pleural cavity. Scheidel<sup>5</sup> removed a rubber drainage tube from the pleural cavity of a man aged 53 who had had the tube inserted seventeen years previously for empyema. The patient suffered much during the seventeen years from recurrent attacks of empyema. Jackson and Jackson<sup>6</sup> reported four cases of intrapleural rubber drainage tubes following operations on the chest. Pereira<sup>7</sup> successfully removed from the pleural cavity a wood splinter which entered as the result of a fall.

#### SUMMARY

Foreign bodies in the pleural cavity are comparatively rare.

A case herein reported is that of a child aged 4 years who suffered from pneumonia and a subsequent empyema. Thoracotomy and rubber tube drainage were instituted. Three foreign bodies within the pleural cavity were later seen in roentgenograms. These foreign bodies were floated out of the pleural cavity with normal saline solution through the thoracotomy wound and proved to be masses of zinc oxide ointment.

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# PERINEURIAL FIBROBLASTOMA SITUATED AT THE JUGULAR FORAMEN\*

NATHAN CROSBY NORCROSS, M.D.

SAN FRANCISCO, CALIFORNIA

PRIMARY intracranial tumors that affect the nerves passing through the jugular foramen appear to be very rare, and a fairly exhaustive search of the literature reveals but few cases in which involvement of the tenth cranial nerve has been a part of the earliest clinical picture.

Stieda<sup>1</sup> in 1928 reported the case of a patient who first showed a weakness of the soft palate and a positive Romberg. The head was carried a bit to the right and the patient tended to fall to this side. This was followed in three months by bulbar speech and papilloedema. Five months later weakness of the face appeared. The patient was operated upon one year after the appearance of the first symptom with a fatal outcome. At post-mortem a tumor was found involving the dura of the right side of the posterior fossa and extending forward to the petrous ridge. The microscopic diagnosis was endothelioma.

Tschernyscheff and Rossels<sup>2</sup> reported, in 1931, a case in which the first symptom was hoarseness due to paralysis of the right vocal cord. This was followed in four years by a decrease in hearing on the right and headaches. Three years later atrophy of the right sternocleidomastoid muscle was noted. The patient died ten years after the onset of symptoms. Autopsy revealed a tremendous tumor involving the right clinoids, the lesser wing of the right sphenoid and the base to the foramen magnum. The microscopical diagnosis was osteosarcoma.

Cases have been reported by Seiffer and Koch<sup>3</sup> and Schwab<sup>4</sup> in which the last five cranial nerves were involved at about the same time. The former was a sarcoma and the latter a carcinoma. Schwabach and Bielchowsky<sup>5</sup> reported a case of involve-

ment of the last eight cranial nerves by a myxofibroma.

A number of other authors have reported cases in which massive tumors have involved this region during their growth. Many of these have arisen from within the petrous pyramid or from outside the base of the skull. There is of course frequent involvement of this area by tumors of the acoustic nerve, that, increasing in size, grow downward, encroaching upon the region of the jugular foramen.

The case presented here is that of a perineurial fibroblastoma which originated at the site of the jugular foramen and involved the nerves passing through it some time before it encroached upon the nerves passing through the internal auditory meatus.

## CASE REPORT

P. S., age 33, was admitted to the Neurosurgical Service August 17, 1927.

In January 1922, the patient had what he called a sore throat and became hoarse. He went to a physician and was told that one of his vocal cords was paralysed. His speech was greatly impaired at that time, but seemed to improve slightly during the next three months and then remained unchanged until admission. In 1924 he noted a marked impairment in hearing not accompanied by tinnitus or other local symptoms. In 1926, he noticed that his vision was not so good as it had been formerly and that he often saw double. At about this same time he became unsteady on his feet and frequently staggered, usually to the right. In September of that year he commenced to vomit, very often during one week, and thereafter about twice daily until the following January. The vomiting was not described as projectile. After January it became less frequent, until at the time of admission it occurred only once every four to six days. In

\* From the Neurosurgical Service, University of Pennsylvania Hospital.

November 1926, he had occasional attacks of shaking of the head that lasted about five minutes and over which he had no control.



FIG. 1. Appearance of patient following operation.

These lasted up until the time of his admission. During the month prior to admission he had a numb feeling in both lips and tongue that was bilateral and slowly progressive. On admission he stated that he had felt increasingly weak and ambitionless during the previous year, and that he had experienced some loss of libido.

He was a painter by trade and had worked with lead paint for a number of years. His wife had had two miscarriages between two healthy children.

Blood pressure on admission was 142/90. Nothing of note was found in the general physical examination. Neurologic examination revealed a clear and alert mentality. Olfaction was normal on both sides. Visual acuity was  $\frac{9}{9}$  in the left eye, and  $\frac{9}{22}$  in the right. The visual fields showed slight concentric contractions. The right optic disc showed 8 diopters of choking and the left, 5 diopters. The veins of the retinae were engorged and a few small hemorrhages were present on both sides. The pupils were unequal in size, the right measuring 4.5 mm. and the left 4 mm. They reacted well to

light and accommodation. There was horizontal nystagmus on lateral gaze to both sides, while on looking upward there were a few rotatory nystagmoid jerks. No limitations of the external ocular movements were noted, but there was a slight weakness of the right side of the face that included the eyebrow and forehead. The eighth nerve was entirely non-functioning on the right side. Taste was absent over the posterior third of the right side of the tongue. Sensation on the right side of the pharynx was much decreased, if not entirely lost, and the patient was unable to feel food when it lodged there. The palatal reflex was absent on the right, and the palate was drawn up and to the left on phonation. The voice was hoarse and monotonous. Dr. Gabriel Tucker reported the right vocal cord to be motionless and in the cadaveric position.

The muscles of the neck were strong on both sides and showed no atrophy, nor was any spasm noted. The tongue was protruded in the midline and showed no atrophy, fibrillation or tremor. Rapidly alternating movements were not done as well with the right arm as with the left, and the finger to nose test on the right side was a bit uncertain. In the vertical plane there was past pointing to the right with the right arm. The head was held inclined slightly to the right, but posture was otherwise normal. There was some swaying while standing on one foot, but there was no true Romberg's sign. When walking in a straight line, the patient staggered four times to the left and once to the right in eight attempts. No changes in sensation were found.

No biceps or triceps reflexes were elicited; the patellar reflex on the left was absent and on the right much decreased. The ankle jerks were equal and active. No pathologic reflexes were obtained.

Lumbar puncture in the lateral recumbent position showed an initial pressure of 260 mm. of water. Examination of the fluid revealed nothing abnormal. The white blood count was 6,600. The hemoglobin was 86 per cent. The urine showed a few hyaline casts.

On roentgen examination of the skull the posterior clinoids and the dorsum sellae were found atrophic. The pituitary fossa measured 12 X 16 mm. There were several areas of rarefaction in the posterior fossa, apparently above the nuchal ridge. There were some areas of calcification in the falx, and the calcified pineal body was not displaced from the midline.

A diagnosis of endothelioma of the cerebello-pontine angle or neuroma of the tenth nerve was made and the patient was operated upon on August 24, 1927.

from the brain stem so that it could be lifted up quite readily with the pituitary rongeurs. We could not determine whether the seventh and eighth nerves ran through the tumor, for

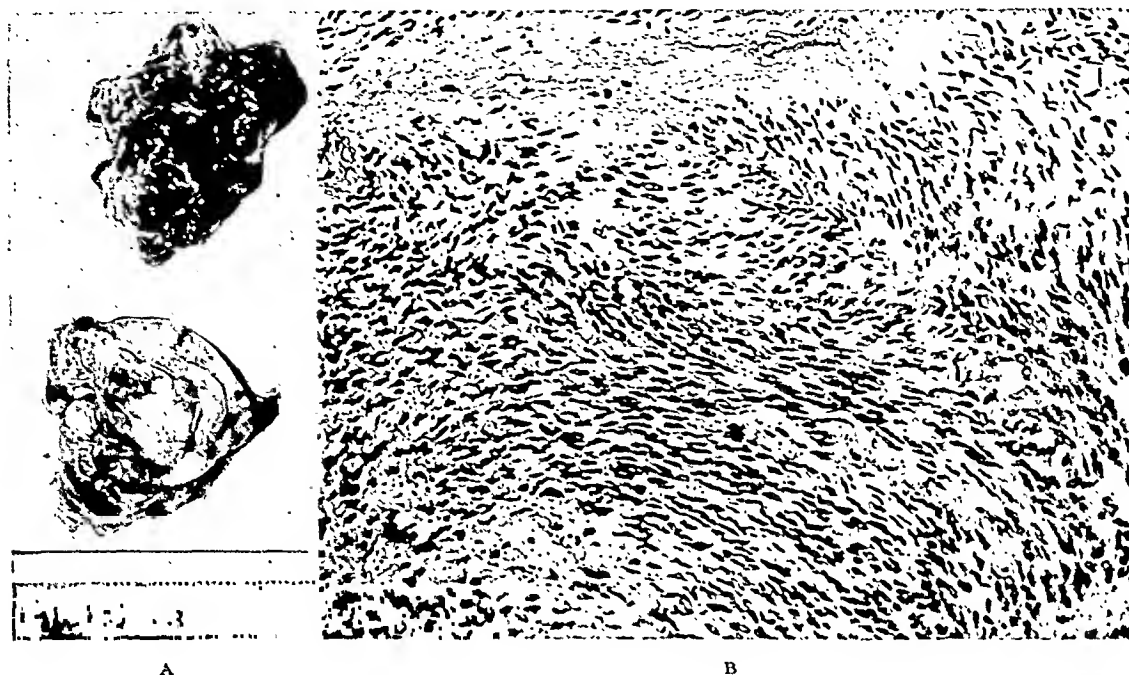


FIG. 2. A, gross specimen. Note the glistening capsule. B, microscopic appearance of tumor, showing the tendency of the nuclei to arrange themselves in parallel rows. In the lower left corner is an area of degeneration, and in the upper right corner the cells are seen loosely packed without much ordered arrangement.

**Operation.** (Dr. F. C. Grant.) A bilateral suboccipital craniectomy was performed. The cross bow incision was carried well out beyond the tip of the right mastoid, and midline incision to the top of the third cervical spine.

The bone was rongeuired away to the right as far as possible. The left ventricle was tapped and found to contain considerable fluid. The dura was opened and the occipital sinus tied. The rim of the foramen magnum and the arch of the atlas were then removed. Nearly all of the right cerebellar hemisphere was exposed and retracted gently, disclosing a hard, discrete, encapsulated, greenish-appearing tumor which had the right eleventh nerve running over its surface. We dissected the nerve off the tumor and could see the fibers of the ninth and tenth nerves running over the surface of the new growth. It was very easy to dissect the cerebellum back from the upper surface of the tumor, and we finally were able to isolate it and roll it somewhat laterally. We then made an incision in the capsule and curetted out the yellow, cheesy material which one often sees in tumors of this neighborhood. The tumor was freed up as much as possible and rolled away

we could not see them at any time. However, it was quite obvious that the nerves running through the jugular foramen were involved. The tumor was removed from its cavity about this foramen with a blunt dissector, with an attempt to preserve the eleventh nerve. The removal of the tumor had no effect on the patient's respiration or pulse and his condition was extremely satisfactory. Hemostasis and closure completed the operation.

Following the operation there was complete paralysis of the seventh, eighth, ninth and tenth cranial nerves on the right. (Fig. 1.) The patient had some difficulty in swallowing and was fed with nasal tube for a few days, but convalescence was otherwise uncomplicated and he was discharged on September 18, 1927. At the time of discharge, in addition to the cranial nerve paralyses mentioned above, he had a suggestive cerebellar gait and a positive Romberg's sign. There was coarse horizontal nystagmus on lateral gaze, more marked on looking to the right. The optic discs showed a subsiding papilledema of 2 diopters. The other cranial

nerves were normal. Tendon reflexes were bilaterally diminished.

The patient was readmitted on December 29, 1927 for facial-hypoglossal nerve anastomosis. At that time he no longer had difficulty with his gait, and coördination was good. His condition was otherwise unchanged. Operation was performed on January 4, 1928, and he was discharged twelve days later.

A letter from him on January 10, 1937, states that he is well and working. His face in repose does not sag and he is able to take fluids without trouble. He has a small scar on his cornea that has been present for two years and has not increased in size. He has some difficulty in swallowing, his voice is still hoarse, he occasionally vomits and staggers in the dark, but these symptoms have not increased during the nine years.

*Pathologic Report.* The gross specimen was in four pieces, two of which are shown in Figure 2. The surface was nodular and tough, consisting of a whitish capsule 1.2 to 2.0 mm. in thickness. In places the capsule was ruptured. The cut surface showed a finely granular, yellow tissue very dense in some areas and soft and necrotic in others.

Microscopically, the tumor showed many areas of degeneration and contained many small cyst-like cavities. In places the tissue was moderately vascular, and some recent hemorrhages could be seen. Between the degenerated areas the growth was very cellular and the cells were arranged for the most part in parallel rows that streamed together. These rows were broken and separated in places by masses of similar cells loosely scattered with no ordered arrangement. (Fig. 2.) The nuclei of the closely packed cells were elongated, and there was a tendency for them to line up in rows, although no true pallisading was seen. The nuclei of the scattered cells were well rounded. In the protoplasm of the cells, fine collagen fibrils ran parallel to the long axes of the cells. Diagnosis: Perineurial fibroblastoma.

#### COMMENT

It is impossible to say from which nerve sheath this tumor arose, but the operative findings would limit it to those nerves passing out through the jugular foramen, and of these the eleventh was little, if at all, affected. In this connection the history of attacks of shaking of the head is interest-

ing, as well as the fact that the patient held his head inclined slightly to the right. These signs might well be considered as due to irritation of the eleventh nerve caused by pressure from the tumor. It seems justified to assume that the nerve sheath from which the tumor arose was that of ninth or the tenth nerve.

The diagnosis of this type of tumor should not, in the majority of cases, offer any great difficulty, as the other causes of such a syndrome are few, and can for the most part be easily ruled out. If signs of increased intracranial pressure have not become apparent, the most likely condition producing a similar picture is inflammation of the common arachnoidal sheath of these nerves (Vernet, 1922<sup>6</sup>), or adenopathy of the glands lying around the jugular vein at its exit from the foramen. Both of these conditions are generally syphilitic and as such offer little difficulty in diagnosis if a Wassermann reaction is done. In cases of trauma, in the form of stab wounds or gunshot wounds of the back of the neck, the cause is obvious and the twelfth nerve is nearly always involved. Extracranial tumors of the nerves or of their sheaths, or of other adjacent structures in the neck may give a nearly identical clinical picture before signs of pressure appear. In some cases, in which the tumor in the neck is small and deep seated, a differentiation may not be possible before signs of pressure become apparent. Large tumors can usually be palpated without much difficulty if care is taken to relax the sternocleidomastoid muscle. These extracranial tumors will frequently be painful on palpation.

Tumors of the base of the skull are the most frequent cause of the syndrome when increased intracranial pressure is present, and if roentgenograms of the base of the skull show no changes in the bone a differential diagnosis is hardly possible. This is not, however, a tremendous disadvantage, as the operative approach in either case would be the same. It is important that the roentgenograms in these cases be taken in the Hirtz position, the so-called "base

plate," as the usual lateral views or those taken in the anteroposterior axis will fail to show any evidence of the slight bone changes seen in early cases. Abscess of the region of the cerebellopontine angle must be thought of, but the history together with the pulse and temperature will usually give the clue. Cysts and cysticercus have been mentioned in the literature<sup>2</sup> as being other possible causes of the syndrome of the jugular foramen.

The fact that this type of tumor is amenable to surgical intervention and can be removed entirely makes the early diagnosis a matter of paramount importance.

#### SUMMARY

A case of perineurial fibroblastoma lying at the inner end of the jugular foramen is

reported. It probably arose from the sheath of the ninth and tenth nerves. The tumor was entirely removed and the patient is well and working after eleven years.

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# PSEUDOPODIAL DIVERTICULA OF THE URINARY BLADDER\*

J. SYDNEY RITTER, M.D., F.A.C.S.      AND

HYMAN LINDER, M.D.

Clinical Professor of Urology, Polyclinic Hospital  
Medical School

Assistant Attending Urologist, Midtown and St.  
Clare's Hospitals

NEW YORK CITY

THE name pseudopodial diverticula alludes to the podial or false, foot-like projections of the diverticula originating from the bladder.

A careful search of the literature for cases of diverticula of this type produced no results, although herniae with diverticula were reported. Rongier<sup>1</sup> of Marion's clinic, Paris, reported a case of inguinal hernia with an infected diverticulum of the bladder containing a calculus. Polkey<sup>2</sup> discusses vesical diverticula and makes the positive statement that these may invade the inguinal or crural canals, but presents no cases. Samuels<sup>3</sup> presented a case of diverticula of the bladder herniating through the left inguinal ring.

Theories of etiology range from the view that congenital origin accounts for the condition to the opinion that obstruction and infection are the active causes.

Joly,<sup>4</sup> Watson,<sup>5</sup> Hyman,<sup>6</sup> Ward,<sup>7</sup> Randall,<sup>8</sup> Pugh,<sup>9</sup> and Moore<sup>10</sup> support the theory that diverticula are of congenital origin. Hinman<sup>11</sup> states that the potential breach in the wall of the bladder is present at birth and the mild distention with each normal micturition may widen it, without presupposing obstruction and increased intracystic pressure. Accessory ureteral buds, vestigial Wolffian ducts and patent urachi explain satisfactorily only a minority of diverticula.

Day and Martin,<sup>12</sup> Herbst, Polkey and Weller,<sup>13</sup> Boardman,<sup>14</sup> Walters and Mulholland,<sup>15</sup> Kutzmann,<sup>16</sup> and Rolnick and McNulty<sup>17</sup> subscribe to the acquired theory of the formation of vesical diverticula. Intrauterine defects of the bladder and obstruction may play important parts in vesical diverticulation. Herbst, Polkey and

Weller produced experimentally diverticula of the urinary bladder in dogs and reached the conclusions that a moderate degree of obstruction, traumatic weakening of the bladder wall and increased intracystic pressure during micturition, such as may be produced by spasmodic contraction of the detrusor muscle due to infection, or other causes of increased muscle irritability, acting over a period of time are three important factors which evidently play important rôles in the formation of diverticula.

Close<sup>18</sup> adds another developmental element in diverticulosis to the five already known: temporary agglutination of urethral mucosa producing retention, superabundance of embryonic tissue (Fig. 1) vestigial Wolffian ducts, supernumerary ureteric buds and patent urachus causing traction from without the bladder. He states, "one must understand the nature of the endopelvic fascia to visualize the importance of the allantoic sheath of Delbet, that condensation of mesoderm which surrounds the bladder apex and laterally from the lateral margins of the empty bladder towards the obliterated umbilical artery. The development of this lateral sheet of fascia has occurred by the divergence in the embryo of the umbilical arteries from the allantois carrying away with them a process of the allantoic sheath from the whole of the allantois. In the filling adult bladder the slack of this process is gradually taken up by its expanding walls, when the whole allantoic sheath is utilized in the development of the bladder, the obliterated umbilical arteries lying in direct contact with the viscus. *Projection of this sheath* into the obturator foramen was found frequently in this *dissection*. Delbet

\* Presented before the Section of Genitourinary Surgery, New York Academy of Medicine, December 21, 1938.



had mentioned it once. Three of five anatomical dissections of the pelvis showed a considerable diverticulum bound to the

hour-glass constriction in its midportion. There were five diverticula arising from the upper and four from the lower half of the bladder.

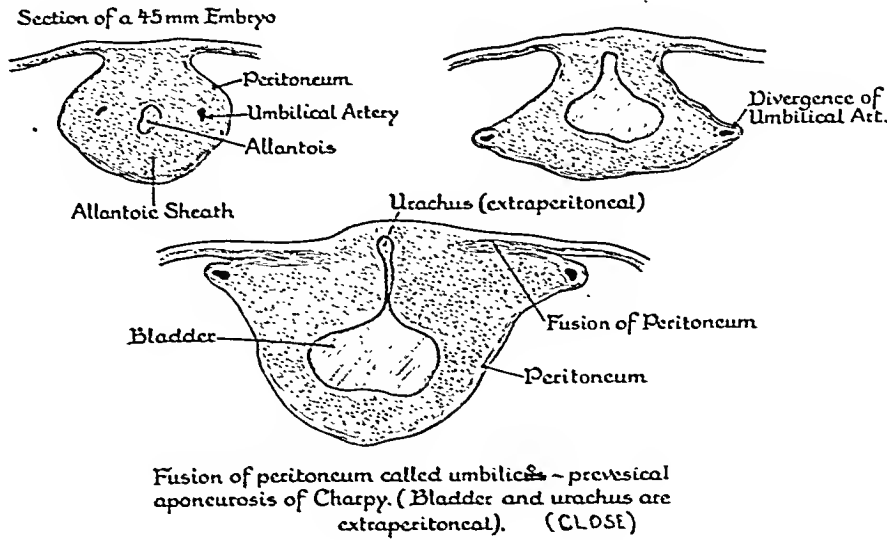


FIG. 1.

attached side, the apex of the mucosal protrusion being held firmly by such an attachment (endofascial). He concludes that traction of fibrous tissue, notably a developmental attachment of the allantoic sheath to the obturator foramen appears to have a predisposing influence in the formation of diverticulum. It was confirmed at operation and autopsy."

#### CASE REPORT

P. M., male, aged 64 years, was admitted to the hospital because of a painful swelling on the inner aspect of the right thigh which had been present for two days. This swelling was about the size of an orange, red, tender, fluctuating and fixed to the muscle tissue though not attached to the femur. Temperature was elevated, pulse rapid. A diagnosis of local abscess was made, the mass incised, and a large quantity of foul smelling purulent material evacuated. The cavity was drained.

Following this operation, the patient never voided. All of the urine drained through the wound, located on the inner aspect of the right thigh, 6 inches below Poupart's ligament. Cystoscopic study was contraindicated due to the septic temperature and debilitated general condition of the patient. A cystographic study, made after the injection of a 5 per cent solution of sodium iodide into the bladder, showed the bladder contracted in size and with an

(Fig. 2.) Four of those arising from the upper half were of small size and resembled the ordinary type of diverticula. Number five was a large pyriform-shaped diverticulum arising from the right side of the upper half of the urinary bladder and extending down into the femoral region through the obturator foramen for 3 inches. Three of the four arising from the lower half of the bladder extended down into the right femoral region and the mid-thigh. The fourth (number nine) extended down into the left femoral region and was divided into three parts by two constrictions. These diverticula ranged in shape from pyriform to curvilinear sausage to pseudopodial forms and varied in size from 2 to 6 inches.

Suprapubic cystotomy was performed on May 19, 1932. A middle vertical suprapubic incision was made. Due to the inability to distend the bladder and to the firm fibrotic adhesions in the space of Retzius, the peritoneum was opened accidentally. This opening was utilized in locating the urinary bladder which was bound down behind the symphysis pubis. The peritoneum was then closed. The bladder was opened and a mushroom catheter inserted for drainage. The patient continued to run a septic temperature, ranging between 100 and 103.6 degrees. There was a large, tense, smooth, fluctuating swelling of the scrotum with a gangrenous area near the perineal attachment. There was also a brawny edematous induration of the perineum as well as of both groins.



With the patient in lithotomy position, two vertical incisions were made into both sides of the scrotum, each draining considerable pus.

trophy of the musculature of the bladder wall with cellulation and sacculation, and increased intracystic pressure produced by



FIG. 2. Explanatory notes of urethrocytogram: R, right side; L, left side; B, bladder, hour-glass in shape; U, urethra; 1-9, diverticula of the bladder; 1-4, diverticula arose from the upper half of the bladder, were small in size and resembled the ordinary type of diverticula; 5, a large pyriform-shaped diverticulum arising from the right side of the upper half of the urinary bladder and extending down into the femoral region through the obturator foramen for 3 inches; 6-8 arising from the lower half of the bladder extended down into the right femoral region and the mid-thigh; 9, extended down into the left femoral region and divided into three parts by two constrictions.

Blunt dissection with the finger through these incisions showed that these cavities extended toward the inguinal region. A 1 inch vertical perineal incision to but not into the urethra, evacuated considerable pus. Further blunt separation through these incisions showed that the cavity communicated with the abscess cavities above. A No. 29 F. urethral sound was passed into the bladder and no stricture was noted. A mushroom catheter was inserted into the bladder and sutured to both the bladder wall and the abdominal wall.

The patient succumbed a few days later. An autopsy could not be obtained.

In the past thirty-two years much has been written about vesical diverticula, but in no instance has a case of multiple hernial formation of diverticula of the urinary bladder been reported.

Obstruction at the neck of the bladder, acting over a period of time, causing hyper-

spasmodic contraction of the detrusor muscle due to infection, played important rôles in causing these diverticula.

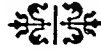
It is possible that the endofascial allantoic sheath of Delbet as described by Close acted as a guide for the diverticulum extending into the right obturator foramen. Following the path of least resistance between already depleted tissue elasticity, and compression and decompression by the muscular tissue on either side, the other diverticula-like moles burrowed snugly and quiescently into their respective positions.

The diverticula here reported were, in our opinion, of congenital origin.

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A ROENTGENOGRAPHIC unit should be a part of the well-planned convalescent hospital, and should be available constantly, for emergencies as well as routine work. Radiotherapy usually would be unnecessary. From—"Convalescent Care" (New York Academy of Medicine).

# URINARY LITHIASIS IN INFANCY AND EARLY CHILDHOOD\*

WITH REPORT OF A CASE OCCURRING IN AN INFANT OF TWELVE MONTHS

FRANK COLEMAN HAMM, M.D., F.A.C.S.

BROOKLYN, NEW YORK

A CAREFUL study of the urinary tract in any large group of children will reveal an astonishing number with diseases requiring surgical treatment. Such disturbances are common and include practically all of the conditions occurring in adults. Much important work has been done in this field, particularly during the last few years. Considering the improved methods that have been developed for the diagnosis and treatment of these cases, and particularly the highly refined instruments that are now available, one is impressed with the thought that urology in children has become a specialty within a specialty.

In the civilized portions of the world, calculi in children are encountered infrequently at the present time. This statement applies particularly to North America. Calculi were not uncommon in England during the nineteenth century when stones were thought to be a disease of the extremes of life, being common among the very young and the very old. In Asia and certain parts of south eastern Europe, calculi are still prevalent. No doubt stones occur in America more frequently than the number of published cases would seem to indicate. It is probable that the syndrome of ureteral or renal colic in children may be mistaken for enteric colic. Bugbee and Wollstein<sup>7</sup> reviewed over 4000 necropsies on infants, finding calculi in the kidneys of thirteen, one of whom was only eleven days old. Clinically, Campbell found eight cases of calculi in a group of 580 children presenting urologic problems. For these observations it is apparent that careful urologic studies in infants and children will reveal the presence of calculi in a fairly substantial percentage of cases.

It is known that calculi may form during the period of gestation. Lagenbeck<sup>13</sup> reported a vesical calculus in a fetus of six months. Rayer<sup>12</sup> stated that renal calculi have been observed at all ages including the fetus and infant. He cited ten cases, two fetuses of six and eight months, three newborn infants ranging from one to eight days, five infants from three to twelve months of age. Bokay<sup>14</sup> has pointed out that during the first few days of the normal infant's life, the urine is extremely rich in uric acid and it is not until the end of the second week that the more usual characteristics of the urine are assumed. It is thought by some that the uric acid crystals or deposits may become nuclei for the formation of larger stones.

Most of the cases of calculi in children reported since 1900 have appeared in the older age groups. Thomas and Tanner<sup>13</sup> collected 203 cases of urinary calculi in children under 15 years of age. Their paper was the result of a general questionnaire sent to members of the American Urologic, American Pediatric and the Central States Pediatric Societies. The average age was found to be 7.8 years. Forty of the total were in children up to 5 years of age; sixty in children between 5 and 10, and fifty-eight in those between 10 and 15. The ages of forty-five were not given. Although forty cases occurred up to 5 years, no definite statements as to the ages of the children and the disposition of the stones are lacking. Campbell<sup>3</sup> has reported on a series of children up to 12 years of age, but does not state the ages of the children on whom he operated.

Several interesting examples of calculus disease occurring in the very young are

\* From the Urologic Service, St. Mary's Hospital, Brooklyn.

recorded in the literature. André<sup>19</sup> reported the case of a boy 13 months old with a right ureteral calculus which required ureterolithotomy. Brown<sup>20</sup> recorded the case of a boy 3 years of age who had a stone in the lower portion of the left ureter. A shadow completely filling the pelvis of the right kidney, and a large sausage-shaped shadow in the lower portion of the left ureter were found on roentgenographic examination. A left ureterolithotomy was done and the sausage-shaped mass was found to consist of nine faceted stones. The convalescence was uneventful.

Hinman<sup>21</sup> reported the case of a girl eleven months old with renal and ureteral stones. The baby, born of healthy Austrian parents, after a normal pregnancy and labor, was breast fed for three months and then given diluted condensed milk. No water other than that contained in the milk was given. Suddenly at eight months, the child had complete retention of urine for three days accompanied by great suffering. The symptoms subsided quickly with the passage of a large quantity of urine and a round stone the size of a pea. The following day severe convulsions were followed by the passage of a second smaller stone, and later three other stones were spontaneously voided. The catheterized urine was cloudy. Microscopically it contained a few red blood cells and many leucocytes and rod-shaped organisms. A roentgenogram showed a shadow in the region of the left kidney and two others in the line of the lower portion of the left ureter. Cystoscopy proved these shadows to be calculi and the left kidney and ureter were removed.

#### REPORT OF A CASE

From a survey of the literature, it appears that the following case is one of the youngest, if not the youngest, case in which a ureteral calculus was found to be producing such a degree of obstruction as to demand urgent surgical removal.

A male infant, N. L., aged twelve months, was admitted to St. Mary's Hospital, Brooklyn,

on December 15, 1937. The history obtained from his Mother showed that he had for the past seven days been irritable and lost appetite.



FIG. 1. Plain x-ray, showing large shadow of ureteral calculus lying in the right lower ureteral area.

Toward the end of the week, he seemed to have a high temperature accompanied by severe pain in the abdomen. He was seen, on the seventh day, by a pediatrician who found the temperature to be 105°F. On deep palpation of the abdomen an indistinct mass could be felt on the right side. Many pus cells and a few red blood cells were found in the urine. No casts or sugar were present. The child apparently had no difficulty in voiding.

Following his arrival at the hospital, an emergency urologic consultation was requested. When first seen, the child presented the picture described above and was critically ill. His pulse ranged between 150 and 160, and his temperature was 104.6°F. He was restless, irritable, appeared to be very toxic and dehydrated, and was in severe pain. The blood count was as follows: leucocytes 37,500, erythrocytes, 4,830,000, neutrophils 49 per cent, eosinophiles 1 per cent, lymphocytes 49 per cent, monocytes 1 per cent. *Bacillus subtilis* and a few Gram-positive micrococci and diplococci were recovered on culture of the urine.

A plain roentgenogram and an intravenous urogram revealed an elongated shadow in the lower third of the right ureter. A diagnosis of a

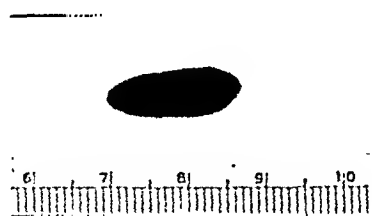


FIG. 2. Photograph of calculus.



FIG. 3. Child six months after operation.

calculus in the right lower ureter was made. (Fig. 1.) In view of the critical condition of the patient, the question arose as to whether the ureterolithotomy should be preceded by a nephrostomy. There was obviously serious urinary obstruction with infection in the renal pelvis and early drainage was clearly indicated. After due consideration, it was decided that removal of the stone might provide adequate drainage, particularly if the incision in the ureter were left wide open. This procedure proved to be a practical solution in this in-

stance. The operation was performed within forty-eight hours of admission.

Under ether anesthesia, a right groin incision was made. The peritoneum was reflected to the midline. On palpation, the calculus was readily identified and milked back for a distance of approximately 4 cm., to make it more accessible for removal. A longitudinal incision, about 1 cm. in length, was made in the wall of the ureter. The calculus was removed without difficulty. (Fig. 2.) The incision in the ureter was not closed by suture because free drainage of the distended renal pelvis and ureter was desired and a Penrose drain was inserted. The wound was closed in layers.

Following the operation, the temperature dropped to 100 degrees on the second post-operative day. It was normal on the fourth day and remained so until he was discharged. Convalescence was essentially uneventful. The infant was dismissed on the eighteenth post-operative day. A chemical analysis of the calculus showed it to be composed mainly of calcium carbonate. The patient was seen six months later when he was in excellent health. (Fig. 3.) No pus or blood was found on examination of the urine and on palpation of the abdomen, no evidence of the original mass on the right side could be felt.

#### DISCUSSION

*Etiologic Factors in Stone Formation.* Stones vary not only in their chemical consistency, but in their size, shape, and position as well. There are many etiologic factors involved in the formation of the varying types. Among those theories given credence in recent literature are the following: (1) The lack of certain vitamin assimilation or utilization. In 1934, a series of experiments was carried out at the Cleveland Clinic in which rats were maintained on a diet deficient in vitamin A for 250 days. Post-mortem study revealed the presence of vesical calculi in 88 per cent and of renal calculi in 42 per cent of the experimental animals.<sup>22</sup> (2) The reduction of content of urinary colloids to the point where they are unable to maintain the urinary salts in solution. (3) The effect of faulty drainage and urinary stasis. (4) A disturbance of the calcium metabolism

brought about by dysfunction of the parathyroid gland. (5) Infection. Infection thrives in the presence of obstruction so that these two phenomena are usually associated. Any of the bacteria commonly found in the urinary tract are seen under these conditions. Probably the most prolific from the standpoint of stone formation is the *Bacillus proteus ammoniae*. This organism has the faculty of splitting the urea of the urine and liberating ammonia, thus making the urine intensely alkaline. Calcareous incrustations and stones composed chiefly of calcium phosphate are the result. (6) Randall's<sup>5</sup> theory is that calculogenesis is but a symptom of some form of renal papillary damage antedating the disposition of crystalline urinary salts. Microscopic studies have shown a hitherto unrecognized papillary lesion consisting of the deposition of calcium in the walls and intertubular spaces of the renal papilla. Once this calcium deposit has lost its epithelial covering it is subject to a constant bath of calyceal urine from which it is naturally assumed that crystals are deposited as upon any foreign body. The concretion grows and then breaks away from its point of origin and passes down the ureter.

Anomalies of the urinary tract undoubtedly predispose to calculus formation. Clinically Hyman<sup>8</sup> found congenital anomalies to be the underlying factor in an analysis of 150 instances of urologic maladies in children. A marked pyuria was associated with all the cases, demonstrating the fact that anomalous urinary organs are very prone to infection. The greatest number of lesions was found in the upper urinary tract. Joly<sup>6</sup> points out that ureteral calculi found in children are often associated with congenital strictures or other anomalies of the ureter. An interesting illustration of an anomaly associated with calculus formation is reported by Burstein.<sup>2</sup> An eighteen month old female had a double kidney with a Y shaped ureter. A calculus was found lodged at the juncture

of the two ureters. A nephrectomy and ureterectomy resulted in recovery.

Chemically, almost all types of calculi have been found, among them being those composed of calcium oxalate, carbonates, phosphates, uric acid and cystine. The uric acid stone is common in the newborn and the cystine stone occurs more commonly before adolescence than afterward. Both types are very smooth and often pass easily through the ureter without becoming impacted. From a study of twenty-one cases of calculi in children, Kretschmer<sup>9</sup> found cystine calculi, pure or mixed, in five cases. Kretschmer agrees with Hyman<sup>8</sup> that cystinuria is a familial and hereditary disturbance of the mechanism of protein metabolism which is often observed in children and predisposed to the formation of cystine calculi. Joly<sup>6</sup> points out that it is most probable that the uric acid infarcts found in the kidneys of infants are not precursors of the type of calculi met in the kidney of the adult. The only type of calculus which he believes is definitely caused by a diathesis, is the cystine calculus.

As has been previously mentioned, calculi are usually associated with infection, under these circumstances stones are likely to be phosphatic. When the stone has not been formed in the presence of infection, it is generally composed of calcium oxalate. The calculus may have a little of each of these elements, but if it is mainly calcium oxalate it has almost surely been formed in an aseptic area. If it is composed in part of phosphates, then it has probably originated in an infected area. The amount of the phosphatic deposit indicates the length of time it has been lodged in the presence of infection. Most of the large stones are of the phosphatic type and grow more rapidly than other varieties.<sup>6</sup> The stones which Kretschmer<sup>9</sup> found in the ureter were composed of cystine or calcium oxalate or calcium oxalate with some phosphate. In one instance of a bladder calculus he found a trace of calcium

carbonate along with magnesium ammonium phosphate and calcium oxalate.

Urinary calculi in children, generally speaking, are not uncommon, but they are seldom found in the ureter. The calculus can usually pass easily through a child's ureter because of its ready dilatability. It is only the very large stones or those which become impacted, that must be removed surgically. Only 10 per cent of the stones formed in the kidney remain there. Of the 90 per cent that leave the kidney, only a few lodge in the ureter; therefore, the remainder of the calculi either are passed from the meatus, stop in the urethra, or remain in the bladder.<sup>3</sup> In summary, Martz and Lewis<sup>16</sup> state that 85 per cent of all kidney stones will pass spontaneously.

Most symptoms of calculus disease are observed during the migratory phases. In moving from the kidney the calculus causes obstruction and mechanical irritation. The back pressure from accumulated urine will cause a marked distention of the organs above the site of obstruction. If persistent, this may result in an enlarged ureter and destruction of renal parenchyma. Primary stones do not originate in the ureter, but in all probability secondary stones do. In children, where a definite urinary obstruction already exists, calculi above that site are usually multiple. Kretschmer also found that in this series five children, or 22.8 per cent, had stones in more than one organ. Both in children and adults calculi are found more commonly in the male than in the female. Jeanbrau<sup>11</sup> has found that the ratio in adults is 3 to 2. Thomas and Tanner<sup>13</sup> and Kretschmer<sup>9</sup> have reported a ratio of 3 to 1.

**Diagnosis.** The diagnosis of ureteral calculus in children may be difficult. It is frequently impossible to get a satisfactory history because of the lack of observation on the part of the attendant, and because the infant himself is unable to describe his difficulties. The symptoms in an older child vary but little from those noted in adults. The symptoms of a ureteral calculus should be distinguished from those of

enteral colic. In the case of stones there is an absence of diarrhea and the attack will be shorter in duration.

Pain is usually the most important subjective symptom. The typical renal colic type, originating in the costovertebral angle and radiating anteriorly down toward the bladder, is often noted. Since renal colic is usually accompanied by vomiting, this may direct attention to the intestinal tract. Calculi that are more or less stationary in the kidney, ureter or bladder may give rise only to a dull ache in the loin or lower part of the abdomen. Such pains rarely radiate. With the migration of the stone, a smooth muscle spasm or colic is usually induced. When the stone is renal or ureteral, the radiation of pain is most often toward the groin, pubis or isilateral genitalia. The pain of migratory vesical stones is frequently referred to the tip of the penis and in the young, often directs attention of the genitalia.<sup>3</sup>

Although pain is a dominant symptom, certain exceptions have been observed. Thompson and Exley<sup>15</sup> report a case of calculus in the ureter of a 7 year 10 months old female who did not have pain. Mertz and Lewis<sup>16</sup> believe that pyuria is the most common symptom of stone in children, with colicky pain next. Pyuria, urinary frequency, dysuria and pain are generally characteristic of calculi. In the event of a severe case of dysuria, a few drops of blood may appear at the end of urination. This symptom is particularly severe when a bladder calculus is present. Prolapse of the rectum may accompany stranguary. Chills and fever are the usual systemic reaction to an acute urinary infection, especially one produced by obstruction. Hematuria is absent in 50 per cent of the cases.

The urinary findings are the most constant and reliable of all. The presence of pus and blood cells in the urine should always lead the clinician to an investigation of the urinary tract. Red blood cells, pus cells, albumin, bacteria and crystals are valuable links in the chain of evidence in cases of obscure abdominal pain.<sup>9</sup> Crystals in the

urine are particularly helpful in diagnosing a cystine calculus. A culture of the urine should be made to determine the presence of infection and the type of offending organism.

A roentgenographic examination is part of the routine study. Pure uric acid stones are not opaque to the Roentgen rays and this may add considerable difficulty to the diagnostic problem. Kretschmer<sup>9</sup> reports that in twenty-one cases of calculi the roentgenographic findings were positive in all but one. A complete urologic survey should be carried out, not only to determine the presence or absence of calculus, but for the purpose of demonstrating any other pathology which might be present. The ureter, whether directly or indirectly involved, may show hypertrophy, dilatation, duplication, elongation or angulation and loop formation with adhesive bands stretching across segments.<sup>1</sup>

Intravenous urography is often a decided aid in diagnosing calculi. This examination may be readily carried out with a minimum of inconvenience to the patient and in many instances will give one the desired information. Where any doubt remains in the mind of the examiner, there should be no hesitancy in making a cystoscopic examination. Certain calculi that are not opaque to Roentgen rays will be picked up on ureteral catheterization or seen as filling defects in the pyelograms. Obstructive lesions at the bladder neck, if present, are easily demonstrated. Cystoscopy may not be necessary in every case but when employed a general anaesthesia is usually required. The instruments now available for cystoscopy are so highly developed that the bladder of even the smallest infant may be successfully examined.

**Treatment.** Surgical treatment depends on the site and size of the calculus. Evidence of urinary obstruction with infection merits serious consideration of its early removal. The surgical procedures employed are essentially the same as those performed on adults; nephrectomy, pyelotomy, ureterotomy, and cystotomy. Children stand

surgery as well as, if not better than, adults, providing certain principles are observed, particularly meticulous control of hemorrhage and the prevention of acidosis. Hemorrhage should be carefully avoided by scrupulous care in effecting hemostasis at the time of operation. If hemorrhage has occurred, the blood loss must be made up by transfusion. The conservation of body heat, the liberal use of transfusions and glucose for beginning acidosis have rendered even the most formidable procedures relatively safe.<sup>3</sup> Wound infections in children are seldom seen and when they do occur recovery is rapid.

#### SUMMARY

1. The recent literature concerning calculus disease in children has been reviewed and a case of ureteral calculus, requiring urgent surgical removal, in an infant 12 months of age has been reported.

2. Stone formation is frequently associated with (a) infection; (b) developmental anomalies of the urinary tract; (c) obstructive lesions.

3. Abdominal pain is probably the most frequent subjective symptom. The presence of pus and blood cells in the urine is the most constant objective finding and indicates the need for further investigation.

4. The management and treatment of urinary calculi in children is essentially the same as in adults. Complete studies should be carried out to determine whether or not anomalies or obstructive lesions are present.

5. When properly handled, children tolerate surgical procedures as well as, if not better than, adults.

6. It would appear that ureteral stones in infancy are probably more common than is generally suspected. Those requiring surgical removal are rare.

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# FEMORAL HERNIA IN INFANCY

## CASE REPORT

NORMAN B. SHEPLER, M.D.

AND

CHARLES W. SMITH, M.D.

Surgeon, Harrisburg Hospital

Chief Resident, Harrisburg Hospital

HARRISBURG, PENNSYLVANIA

THE patient was a colored female infant born in the Harrisburg Hospital August 1, 1938, whose weight at birth was 4 pounds 3 ounces. She received premature care, developed normally and at the time of her discharge from the hospital on August 16, 1938, weighed 5 pounds and  $\frac{1}{4}$  ounce.

She remained perfectly well until the night of October 8, 1938 when she began to cry as if in pain. The mother noticed a swelling in the left groin. When she touched the swelling the baby cried with more intensity.

Physical examination on admission revealed a swelling the size of a walnut in the left groin below Poupart's ligament. This swelling was firm and tender, did not transmit light, was dull to percussion and irreducible by taxis. The diagnosis of left strangulated femoral hernia was made.

Under general ether anesthesia a small incision was made parallel to and below Poupart's ligament. The diagnosis of femoral hernia was confirmed. The hernial sac was isolated and incised and found to contain the left Fallopian tube, the left ovary and a small parovarian cyst, the latter being somewhat discolored. The ectopic organs were replaced in the peritoneal cavity, the sac was ligated and the femoral ring was closed with two mattress sutures of o chromic catgut which were reenforced with a third suture. The superficial tissues were closed with interrupted fine catgut sutures and the skin with fine interrupted wire. A water-tight occlusive dressing was applied.

The child made an uneventful recovery. She was kept on breast milk with the addition of a complementary formula during her hospitalization. There was no postoperative vomiting or distention. The sutures were removed on the fourteenth postoperative day at which time the incision was healed completely, and the patient was discharged on the eighteenth day.

*Incidence.* Erdman<sup>9</sup> states that only 1 per cent of all femoral hernias occur in childhood. Watson<sup>27</sup> and Tasche<sup>24</sup> find

them very rare before the twentieth year and Tasche did not believe that femoral hernias have been reported in any individual under 2 years of age. Denoeux<sup>8</sup> cites a paper by Werhner who collected 5,341 cases of femoral hernia, none of which were in children under 1 year of age, seven occurring between the ages of 1 and 5, and thirty-four between the ages of 6 and 10. Lloyd<sup>16</sup> discovered only one example of femoral hernia in three years at the Hospital for Sick Children, London; this was in a 5 year old male. Herzfeld<sup>11</sup> reported a series of 1,000 cases of hernia in children up to 12 years of age, only four of which were femoral hernias. Balch<sup>1</sup> discovered three cases of femoral hernia in patients under 10 years of age in a series of 100 cases of femoral hernia occurring at the Massachusetts General Hospital between 1924 and 1933. In Shawan and Altman's<sup>23</sup> series of ninety-seven cases, the youngest patient was 19 years of age. Coley<sup>4</sup> found 101 cases of femoral hernia in a series of 3,000 cases, twenty-one of which were in patients under 15 years of age. Rutherford<sup>21</sup> reported a series of 1,098 cases of hernia from the Belgrave Hospital, London, where the age limit for admission is 10 for girls and 12 for boys. He found only five cases of femoral hernia in the entire group. Rutherford also cited the statistics of Ribera y Sans from the Hospital l'Enfant Jesus, Madrid, who reported fourteen cases of femoral hernia out of a total of 3,098 cases of hernia. Horsley<sup>12</sup> states that although any type of hernia seen in the adult may be encountered in the practice of pediatrics, femoral hernias are seen very rarely. Approximately 70 per cent of all hernias seen in children are of the indirect inguinal type and 30 per cent of the umbilical type.

Indirect evidence of the rarity of femoral hernias in infancy is found in the thorough review articles<sup>14, 17, 18, 20</sup> of strangulated hernias in infancy; in none of these articles is there a case of femoral hernia reported.

*Sex.* Cumston<sup>6</sup> says that after the age of 25 femoral hernias are more frequently seen in women than in men, but that in young subjects the defect is more frequently observed in boys than in girls. In Coley's series<sup>4</sup> eleven of the twenty-one cases occurring under 15 years of age were in boys and ten in girls. Four of Rutherford's<sup>21</sup> cases were females and the fifth was a male. Herzfeld<sup>11</sup> also found four cases in females and a fifth in a male. Watson<sup>27</sup> feels that femoral hernias in infancy are as common in one sex as in the other.

*Side Involved.* Femoral hernias usually occur on the right side, according to Erdman<sup>9</sup> twice as often as on the left. Watson<sup>27</sup> states that femoral hernias in children and infants are usually unilateral, but Coley<sup>4</sup> found two cases of bilateral involvement in male children.

*Pathogenesis.* There is a great deal of disagreement as to whether or not femoral hernias can be congenital in origin. Cowell,<sup>5</sup> Tasche,<sup>24</sup> and Denoeux<sup>8</sup> all feel that a congenital theory cannot be advanced as a cause. Tasche says that no femoral diverticulae are ever found in otherwise normal newborn infants. They find femoral hernias increasing in number with advancing years, in patients who have large increases in body weight with consequent loss of muscle tone, in patients, who suffer with chronic debilitating diseases, especially asthma. They also point out that these hernias occur far more often in parous women than in the childless.

On the other hand, Watson<sup>27</sup> feels that the congenital origin of femoral hernias is most widely accepted today. He is supported by Murray<sup>19</sup> who, in 200 consecutive necropsies, found fifty-two bodies with peritoneal femoral diverticulae, fourteen of these presenting the defect bilaterally. Watson feels that the predisposing factors

are the presence of a preformed sac or prominence of a peritoneal depression due to lack of fat. He also cites absence of the lymph gland of Rosenmüller, a large saphenous opening or a large compressible femoral vein as possible predisposing factors.

A number of authors<sup>3, 24</sup> have pointed to the regularity with which a pad of adipose tissue is found in association with a femoral sac. These men seem to feel that this lipomatous pad is in some way linked to the occurrence of the hernia.

Velasco Blanco and Eschegarez<sup>26</sup> think that femoral hernias in children may be either acquired or congenital. In the former there is an outward propulsion of peritoneum, while in the latter there is a preformed peritoneal diverticulum.

*Diagnosis.* The position of the hernial mass is very important in arriving at a diagnosis. Femoral hernias lie below Poupart's ligament and external to the pubic spine, whereas inguinal hernias lie above Poupart's ligament and internal to the pubic spine. With reducible hernias pressure upward and outward is required to accomplish reduction of an inguinal hernia, while pressure downward and backward is necessary to reduce a femoral hernia.

The differential diagnosis has been thoroughly discussed by various authors.<sup>1, 5, 9, 12, 25, 27</sup> The chief considerations are inguinal hernia; psoas abscess where we often see spinal symptoms, gurgling in the mass being absent; lymphadenopathy in which we find no gurgling, no impulse with increased intra-abdominal pressure, no neck to the mass and frequently several nodes in a group; varix of the saphenous vein, in which there is filling from below; lipomas, dough-like in consistency and frequently bosselated; and a few other infrequent conditions such as undescended testicles, obturator hernias and cysts of the inguinal canal or of the canal of Nuck.

*Contents.* Omentum and small intestine are most commonly found, but in extremely young infants the omentum is not well developed. Rutherford's<sup>21</sup> case in a 4 year

old female contained only omentum. However, at some time or other almost any of the abdominal viscerae have been reported in femoral hernias.

Gore<sup>10</sup> and Watson<sup>27</sup> call attention to the fact that frequently the sacs of femoral hernias are empty. Lloyd<sup>16</sup> reported a case of strangulation of an empty sac in a 5 year old boy.

The Fallopian tube is not often found in the sac of a femoral hernia because in a normal anatomic arrangement the tube lies at a lower level than the femoral ring. Several interesting cases have been reported: Baty<sup>2</sup> found a well developed Fallopian tube strangulated in a femoral hernia in a male patient 29 years of age. Johnston<sup>13</sup> found the right tube incarcerated in a 30 year old female. Denoeux<sup>8</sup> cites a case report by Pillon who found a tube, ovary and appendix strangulated in a child 21 months of age. Daggett<sup>7</sup> found a tube and ovary incarcerated in a right inguinal hernia in a baby 7 weeks of age.

**Treatment.** All writers are agreed that the use of a truss has no place in the treatment of a femoral hernia in infancy and childhood. Operative treatment is the only successful method. Herzfeld<sup>11</sup> recommends exposure of the sac through the inguinal canal and makes no attempt to close the actual gap in the crural ring. She feels that ligation of the sac is a sufficient procedure. Coley<sup>4</sup> uses the femoral approach with closure of the femoral canal by a purse-string suture. He feels that this is the simplest procedure and his incidence of recurrence is no higher than that of others who use other techniques.

#### SUMMARY

1. Femoral hernias are of very rare occurrence in infancy, the patient reported here being probably one of the youngest in the literature.

2. The occurrence of a femoral hernia in an infant so young tends to lend weight to

the theory that femoral hernia can be congenital in origin.

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# STRUMA LYMPHOMATOSA (HASHIMOTO)\*

JOSEPH ZISKIND, M.D.

AND

HERBERT J. SCHATTENBERG, M.D.

Pathologist, Charity Hospital

Professor of Pathology, Tulane University  
Graduate School of Medicine

NEW ORLEANS, LOUISIANA

**A**MONG the most interesting diseases affecting the thyroid gland is that of chronic nonspecific thyroiditis. This condition went unrecognized as an entity until 1896, when Riedel<sup>1</sup> described a thyroid gland which was characterized by enlargement, iron hardness and extensive adhesions surrounding and adherent to it. When removing the gland, Riedel felt that he was dealing with a malignant neoplasm, but on histologic examination the pathology was interpreted as a chronic inflammatory process. The fact that this was benign and non-neoplastic was confirmed by the clinical course, since the thyroid had only been partially removed. Because of the marked firmness of the gland, Riedel referred to this condition as "eisenharte strumitis."

In 1912, under the title of "struma lymphomatosa," Hashimoto<sup>2</sup> described four cases having similar subjective symptoms to those reported by Riedel. These occurred in women all over 40 years of age. The disease was slow, insidious in onset and at operation was adherent to the trachea but not to the other surrounding structures. Following operation during which both lobes of the thyroid gland were removed in all four cases, there was a slow recovery which took twelve to eighteen months. Symptoms suggestive of postoperative hypothyroidism developed in two patients. Microscopic examination of the gland revealed a diffuse lymphocytic infiltration with numerous lymphoid follicles and germinal centers. Some degree of fibrosis, atrophy and hypertrophy of the glandular tissue was noted. Hashimoto found no specific etiology for the condition, but felt

that this disease was a different entity from that of Riedel's struma.

Considerable argument has ensued concerning the possible relationship between these two conditions. In 1922, Ewing<sup>3</sup> suggested that struma lymphomatosa was an early stage in the development of Riedel's struma. Williamson and Pearce<sup>4</sup> and Jaffe<sup>5</sup> came to a similar conclusion. However, there have been opposite viewpoints especially by Joll<sup>6</sup> and Graham and McCullagh.<sup>7</sup> The latter authors point out that struma lymphomatosa is found almost entirely in women over 45 years of age, but that Riedel's struma, although usually found in adults, may occur at any age and is noted almost as frequently in men as in women. They state further that Hashimoto's struma is a diffuse one, whereas Riedel's struma may involve an entire or part of a lobe. These observers note also that in lymphadenoid goiter there is a diffuse formation of a delicate connective tissue in the later stages, whereas dense connective tissue may be found in the earlier stages of Riedel's struma. Finally these authors state that Hashimoto's struma operated or unoperated upon tends to develop signs and symptoms of hypothyroidism while Riedel's struma will rarely do so.

The etiology of both conditions is still unsettled. Riedel's struma appears to have some definite infectious factor. Graham<sup>8</sup> states that Riedel's struma "may be looked upon as having a local inflammatory process in the thyroid for which an etiological factor should be sought. The general body economy is affected secondarily by reason of destruction of the thyroid,

\* From the Department of Pathology, Tulane University School of Medicine and the State Charity Hospital of Louisiana, New Orleans.

interference with respiration and deglutition, and injuries to important blood vessels and nerves."

for the disease's occurring mainly in women after the menopause by this predisposing involution.



FIG. 1. View showing diffuse lymphocytic infiltration, some fibrosis and decreased number of thyroid acini.

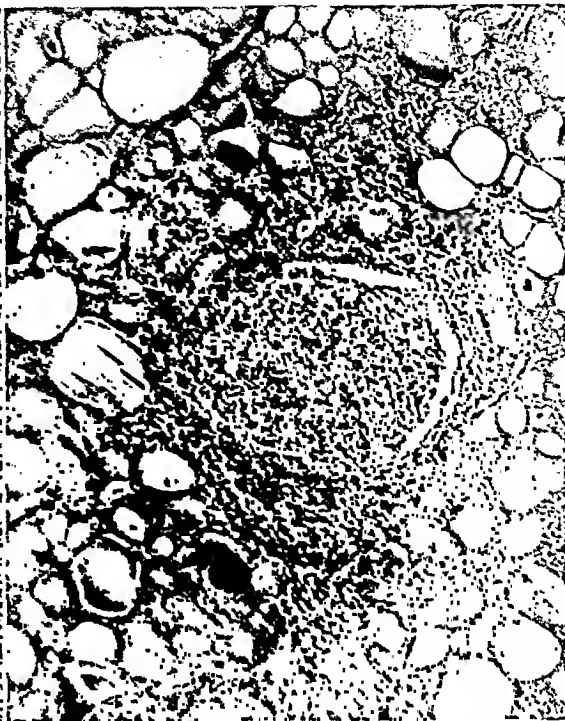


FIG. 2. Section showing lymphoid follicle with large germinal center in which there is active proliferation.

Williamson and Pearse<sup>4</sup> suggested that Hashimoto's struma is a pathologic variant of a lymphogenic secretion which is a normal function of the thyroid gland. McCarrison<sup>9,10</sup> was able to produce a condition simulating lymphadenoid goiter in rats by feeding them a diet deficient in vitamins but containing iodine. Graham and McCullagh<sup>7</sup> consider also that an antecedent hyperthyroidism may be a precursor to struma lymphomatosa and Graham<sup>8</sup> further states that "Hashimoto's type of lesion may be considered to be a local manifestation of a constitutional disorder—the changes in the thyroid tend to become degenerative rather than inflammatory and sclerosing." Jaffé<sup>5</sup> believes that any infection may lead to nonspecific degenerative changes of the thyroid gland with a secondary lymphatic reaction. He thinks further that those glands are predisposed to degeneration which are either hypoplastic or the site of a pathologic or physiologic involution. He tries to account

#### CASE REPORT

L. R., a colored female, age 36, was admitted to the hospital on August 29, 1938 with a complaint of swelling in the neck for several years past. During the month before admission she experienced symptoms of choking and insomnia, and occasional attacks of palpitation and fatigability. Her past and family histories were irrelevant.

She was fairly well developed and did not appear acutely ill. There was no exophthalmos or other ocular sign of hyperthyroidism. The pupils were equal and reacted well to light and accommodation. The tonsils were somewhat infected. The thyroid gland was diffusely enlarged, lobulated and very firm. The lungs were clear, the heart not enlarged, but a systolic murmur was heard over the mitral area. Temperature was 98.6°F., pulse 85, respiration 18 and the blood pressure 190/125.

Urine examination was negative as was the blood Wassermann. The electrocardiogram showed some changes suggestive of myocardial disease. X-ray examination revealed no signs of pressure or displacement of the trachea, and

there was no evidence of intrathoracic goiter. The basal metabolic rate was plus 8.

On September 17, 1938, a total resection of

cytes were less abundant, appearing as loose accumulations in the interstitial tissue, and the acini were not compressed. Here and there



FIG. 3. Section of thyroid gland showing lymphoid follicle, lymphoid cell infiltration between acini and atrophy of acini with reduction of the colloid content.



FIG. 4. Groups of acini being infiltrated by lymphocytes, showing the reduced amount of colloid, which is often basophilic, and the peculiar large degenerating epithelial cells.

the thyroid gland was done. The thyroid was enlarged and hard in consistency. It was not adherent to the surrounding structures except for some adhesions between the isthmus and the anterior surface of the trachea.

On the day following the operation the patient's temperature went up to 102°F. but dropped again very quickly. No other complications occurred. The wound healed well and she was discharged seven days following the operation. Since her discharge she has remained well and has shown no signs of hypothyroidism.

**Pathologic Report.** The specimen consisted of both lobes of the thyroid gland with the isthmus. It was half moon shaped and measured  $13 \times 4 \times 2$  cm. The gland was very firm in consistency and well encapsulated. The cut surface was rather pale pink and homogeneous throughout. No colloid material could be seen on gross examination. Microscopic examination showed a diffuse infiltration of the stroma with lymphocytes, which, however, varied in amount in different parts of the sections. In some situations the cells occurred in large numbers and between them atrophic acini were present. (Fig. 1.) In other microscopic fields the lympho-

lymph nodules with germinal centers were noted. (Fig. 2.) The acini were in general uniformly small and contained either no colloid or reduced amounts. (Fig. 3.) The colloid stained poorly and in many instances was basophilic. There was some increase in the interlobular connective tissue stroma. The acini were normal in size, lined by flat epithelial cells and contained colloid. Where there was greater infiltration the acini were atrophic and lined by relatively large pale, acidophilic cells with granular cytoplasm, irregular nuclei and contained reduced amounts of colloid. (Fig. 4.) In some instances epithelial cells and lymphocytes were seen within the lumina.

#### COMMENT

Hashimoto's struma is almost always found in women. The average age in Graham's<sup>8</sup> and McClintock and Wright's<sup>11</sup> combined series of fifty cases was 49.2 years. They found that the symptoms were usually present for an average of sixteen months, with the duration of goiter slightly over four years. These authors



noted that in the fifty reported cases of struma lymphomatosa, all had involvement of both lobes of the thyroid and three-fourths of those suffering from Hashimoto's disease developed hypothyroidism following removal of the gland.

In contrast to these findings in Riedel's struma, the authors noted that sex was not an important factor and the average age of individuals suffering from this disease was 40 years. They found that in Riedel's struma the average duration of symptoms was about seven months while the goiter was present for an average period of 3.5 years. In this condition, the process, in approximately 30 per cent of cases was found to involve one lobe only and following operation about 26 per cent developed hypothyroidism.

McClintock and Wright<sup>11</sup> believe that there are certain signs and symptoms which may differentiate these two conditions, Riedel's struma is tender, very firm, fixed and resistant. Hashimoto's struma is resilient and more often gives symptoms of weakness and fatigue. Both types may cause dyspnea, dysphagia and a feeling of tightness about the neck. Patients with Riedel's struma following surgical treatment tend to improve rapidly and completely, whereas those with Hashimoto's disease have a long convalescence with frequent development of hypothyroidism.

In Hashimoto's disease, the shape of the gland is preserved. Both lobes and the isthmus of the thyroid are usually enlarged. The enlargement is intracapsular and the gland is not adherent to surrounding structures except occasionally to the trachea. The consistency is firm and the gland cuts with increased resistance. The tissue is pinkish white in color and definite trabeculae can be seen. Normal thyroid tissue cannot be made out grossly. Microscopically, although some fibrosis is present, the characteristic picture is that of a diffuse lymphoid infiltration between the acini. Numerous secondary lymphoid follicles are present and these may be very large in size. The lymphocytic infiltration

varies in different parts of the gland. It is most marked in the interacinar tissues and in other parts of the gland it may be minimal in amount or totally absent. In the dense portions of lymphocytic infiltration, the acini are compressed and atrophic. The epithelial cells of these atrophic acini are peculiarly acidophilic, large, and have an increase in cytoplasm and a hyperchromatic nucleus. These cells are similar to those seen in degenerative processes. There is a diminution or absence of the amount of colloid within these acini. Only in occasional instances are plasma cells present. Organization of the lymphoid tissue into a definite node does not occur. In patients with hyperthyroidism, especially those who have taken considerable iodine, it is not uncommon to notice lymphocytic infiltration or even follicle formation. Differentiation can be made from struma lymphomatosa by the lack of thyroid hyperplasia, and atrophy of the thyroid tissue with the peculiar acidophilic cells described above in the latter condition.

Riedel's struma has a tendency to become fixed by adhesions to the neighboring structures but very seldom to the skin. The gland is very hard in consistency and because of this is often mistaken for malignancy although it does not have the irregular nodularity of cancer. The borders of the organ are not very definite and this finding is more marked when the gland becomes attached to the surrounding structures. The capsule is usually thickened. The cut surface is white in color and normal thyroid tissue is not evident grossly. On histologic examination, the characteristic picture is that of fibrosis. The fibrosis may vary from an increase in the interacinar and interlobular connective tissue to complete replacement of the thyroid parenchyma by dense connective tissue. The fibrous tissue is most marked beneath the capsule. There may be smaller or larger amounts of lymphocytic infiltration with occasional plasma cells. The acini which are still present are atrophic and show evidence of degeneration. Occasional areas of epithelial



hyperplasia may be noted. Giant cells frequently occur in the region of degenerating acini. Lee<sup>12</sup> believes that these are due to fusion of epithelial cells about colloid droplets.

#### SUMMARY

A case of struma lymphomatosa (Hashimoto) is reported with the clinical and pathologic findings.

This disease is uncommon.

The characteristic pathologic finding is a firm thyroid gland which microscopically shows a diffuse lymphocytic infiltration with lymphoid nodules.

Struma lymphomatosa is considered by some to be an early stage of Riedel's struma, but there are an increasing number of observers who feel that these conditions are separate and distinct diseases.

The etiology of Hashimoto's disease is as yet unknown. A general comparison of the clinical and pathologic differences between Hashimoto's and Riedel's struma is given.

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# APLASTIC KIDNEYS\*

## CASE REPORT

J. K. DE VRIES, M.D.

NEW YORK CITY

**A**PLASIA of the kidney is always an interesting condition and at times one which presents a problem in

At age 12, the patient had spent three years in a sanatorium for the treatment of pulmonary tuberculosis. Since that time she had been free



FIG. 1. Flat x-ray of the KUB tract. The right kidney is well visualized and slightly larger than normal in size. In the left kidney region an irregular, dumbbell-shaped mass is noted.



FIG. 2. Five minute excretory urogram shows good function and normal structure on the right side. No dye is visible on the left.

diagnosis. In the present case the differential diagnosis had to be made between aplasia and tuberculosis of the kidney.

### CASE REPORT

Mrs. G. M., 31, was admitted to the Brady Urological Service on October 11, 1938 complaining of pain in the *right* costovertebral region. Her illness had developed one month before admission with pain the only symptom present. It was dull, localized, and intermittent in character. Three weeks before admission, an intravenous pyelographic study done elsewhere had shown no excretion of dye from the *left* kidney.

from any clinical evidence of tuberculosis. Pulmonary x-rays taken eighteen months previously were reported negative.

Appendectomy and removal of an ovarian cyst were performed in 1936. At this time a bicornuate uterus was found.

On physical examination the lower pole of the right kidney was palpable and slightly tender to deep pressure. The left kidney was not palpable or tender. No masses were detected in the abdomen.

**Laboratory Findings.** In the bladder urine, a few white blood cells were found. Sedimentation of the bladder urine and stain for tubercle bacilli were negative on two occasions. Cultures of urine from the bladder and right ureter were

\* Presented before the Section of Genitourinary Surgery, New York Academy of Medicine, November 16, 1938.

sterile. Vaginal secretion showed many white blood cells, but no gonococci and no trichomonas. A three hour P.S.P. test showed 68 per cent

Exploratory operation was done eleven days after admission, by the lumbar route. Upon opening Gerota's fascia posteriorly, palpation in



FIG. 3. Cystogram shows a smooth defect on the left side of the bladder.

of dye eliminated, with a normal curve. Blood urea was 11 mg. per 100 c.c., blood sugar 67 mg. per 100 c.c. The hemoglobin was 94 per cent, red blood count 4,600,000, white blood count 6,200, with adult polys 62 per cent; immature 6 per cent; lymphocytes 30 per cent, monocytes 2 per cent. The Kline test was negative.

**X-ray Examination.** A chest film revealed no evidence of recent or active tuberculosis. The excretory pyelograms showed good and normal function from the right side, no function at any time from the left side, but multiple rounded calcified cyst-like shadows in the plane of the mid-abdomen. The bladder shadow was deformed on the left side.

At cystoscopy the bladder was normal. There was no evidence of inflammation or ulceration. No left ureteral orifice could be found. Indigo carmine, injected intravenously, failed to be excreted from the left side. Retrograde pyelography added nothing to the evidence obtained by excretory pyelography.

Seven days after admission 150 c.c. of air was injected into the left renal fossa and stereoscopic plates were made. This study failed to give much additional information. The cyst-like shadows previously described were of about the same appearance. The psoas shadows were clearly defined.



FIG. 4. X-ray of the tissue removed at operation.

the renal fossa revealed two small cyst-like masses. The superior mass was dissected free from the surrounding fatty tissue and was found to connect with a lower larger cyst-like mass by means of a thick band of fibrous tissue. The whole mass was dissected free and found to be attached to a structure having the appearance of an infantile ureter. This structure was ligated and cut, freeing the mass which was then removed in toto. Further exploration of this left renal fossa revealed no further evidence of a kidney.

The patient made an uneventful convalescence and was discharged as cured fourteen days after operation.

**Pathologic Examination.** In one of five sections, a small amount of adult kidney tissue was found. Throughout the other sections there were numerous small and large duct-like structures lined by columnar epithelium and surrounded by muscle. Numerous blood vessels were noted throughout the fibromuscular stroma. The cysts were lined by a layer of calcified tissue which in some fields had gone into bone formation. The tissue connecting the cysts was loose, infiltrated with lymphocytes, and there were several fields of hemorrhage.

#### SUMMARY

In favor of the diagnosis of a functionless tuberculous kidney on the left were: (1) the history of previous pulmonary tuberculosis; (2) absence of function from

the left kidney; (3) calcified areas in the left kidney region.

Against the diagnosis of tuberculosis

made and confirmed by operation and pathologic examination.

Injection of air into the renal fossa was

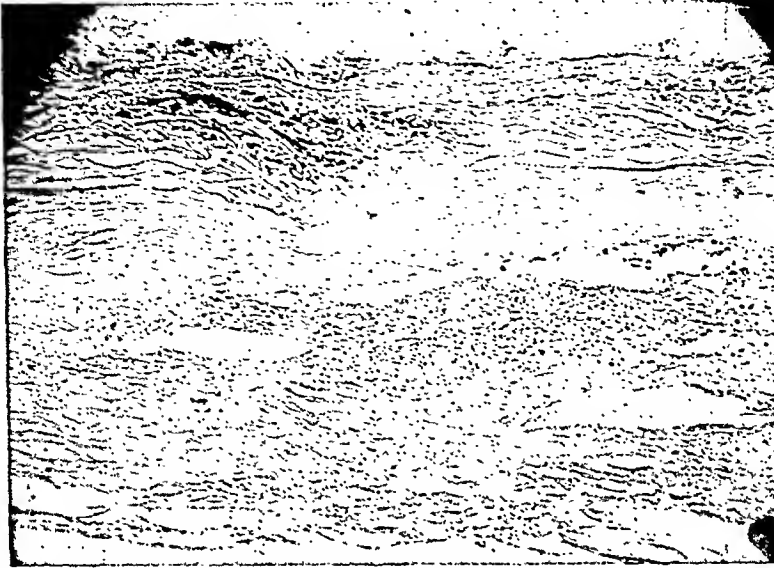


FIG. 5. Photomicrograph. This is characteristic of most of the tissue removed. It consists of fibrous tissue with infiltration of lymphocytes and leukocytes.

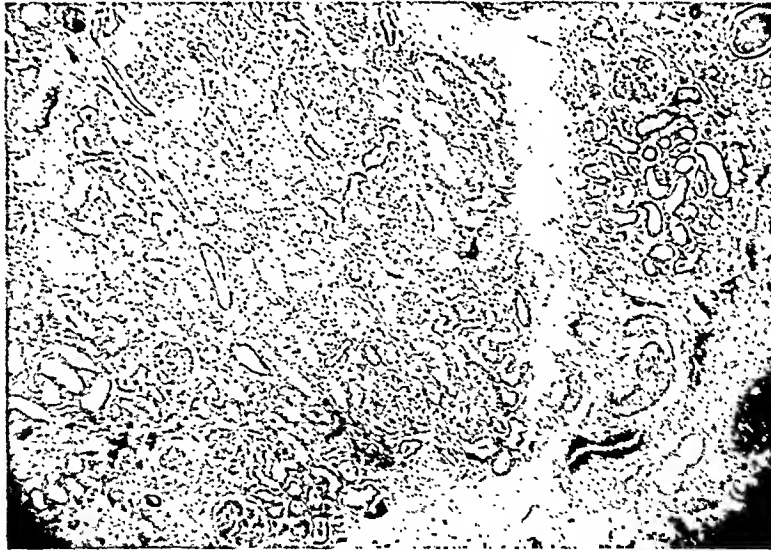


FIG. 6. Photomicrograph of tissue removed. A very small area of adult kidney tissue with marked destruction of glomeruli and dilatation of tubules and scar tissue replacement.

were: (1) the absence of urinary symptoms; (2) the normal bladder mucosa; (3) failure to find tubercle organism in the urine.

In favor of aplasia of the kidney were: (1) the presence of a bicornuate uterus; (2) absence of the left ureteral orifice and smooth deformity of the left side of the bladder; (3) absence of function from the left kidney. The diagnosis of aplasia was

used as an additional aid in diagnosis. This procedure carries with it the danger of air embolism and is open to criticism on that ground.

The patient has experienced no pain since operation. It is difficult to explain this happy circumstance by nephrectomy. It is also too early after operation to be sure that the pain will not recur. In the meanwhile we have dilated the right ureter.

# KIRSCHNER WIRE EXTENSION FOR TREATMENT OF OVERRIDING FRACTURES OF THE CLAVICLE\*

WALTER I. GALLAND, M.D.

Orthopedic Surgeon and Chief of Clinic, Lenox Hill Hospital

NEW YORK CITY

THE correction of overriding fractures of the clavicle not infrequently present a problem of some difficulty. part any obvious scarring should be of distinct service. Inasmuch as the clavicle acts to main-



FIG. 1. Front view of patient with traction arch jacket. The action of the elastic pull upon the clavicle can be seen by the manner in which the shoulder is elevated and by the accentuation of the clavicle which is drawn into relief along its entire subcutaneous length.



FIG. 2. Lateral view, showing direction taken by the Kirschner wire as can be seen by the diagonal position of the Kirschner spreader. Note position of the plaster arch. The arm is entirely free and can be used for all normal activities.

Numerous methods have been contrived to overcome this deformity. Most of these methods aim to pull the point of the shoulder outward, upward and slightly backward in order to reestablish the normal distance between the sternoclavicular and the acromioclavicular joints. At times the closed methods commonly used are unsuccessful. It is then necessary to resort to open reduction, which, on account of the resultant scar, is sometimes undesirable from a cosmetic standpoint; therefore a method which overcomes for the most

tain the distance of the shoulder from the trunk, it is obvious that when fractured, the entire shoulder girdle is apt to fall medially forward and downward, carrying with it the outer fragment of the clavicle, and in case of a complete fracture which becomes disengaged the two fragments override. To secure reposition, therefore, it is necessary that the normal position of the shoulder be reestablished. The mechanism of reposition must be one which pulls the shoulder and concomitantly the

\* From the Orthopedic Service, Lenox Hill Hospital, New York City.

outer end of the clavicle, outward, upward and slightly backward. It is a general experience that the maintenance of such a position by any piece of ambulatory apparatus is most difficult, and for this reason the application of direct skeletal traction was considered as a desirable addition to the methods of treatment already in use.

In selecting the site of application of this traction, an easily accessible bony point removed from any important contiguous structures had to be chosen. The prominence finally taken was the acromion process of the scapula. The clavicle is attached to the acromion process by means of extremely strong ligaments through an articulation which permits the direct transmission to the clavicle of any traction force applied to the acromion. The insertion of a wire through the acromion is relatively simple since that bone can be palpated in a subcutaneous position throughout its entire extent. The wire should be placed through a portion of the bone which will bear the stress without danger of having the wire tear out. The acromion is a rather broad and thin process. The superior subcutaneous surface is directed upward dorsally and somewhat laterally, while the inferior surface overhangs the shoulder joint. A wire which penetrates the entire thickness of this bone does not of necessity enter the shoulder joint proper. In order to avoid that articulation, however, it is desirable that a wire should be so inserted as approximately to parallel the plane of the posterior superior surface of the acromion. It is not difficult to insert a thin Kirschner wire through the acromion in this plane under local anesthesia, and a wire so inserted has a firm hold upon the shoulder girdle.

In introducing the Kirschner wire, the spine of the scapula should be palpated until the expansion which forms the subcutaneous surface of the acromion is reached. A site is selected  $\frac{3}{4}$  inch medial to the tip of the process. At this point the Kirschner

wire is inserted in an upward and forward direction, approximately paralleling the posterior superior surface of the bone,



FIG. 3. Close-up view, showing the distance which has been maintained between the Kirschner spreader and the plaster arch to permit the application of rubber band traction. The rubber bands span the space between the Kirschner spreader and the arch.

traversing the acromion from its posterior to its anterior edge. Inasmuch as the side of the wire is of necessity held almost against the skin below the acromion, it will be found helpful to depress the skin away from the wire by means of a sterile flat spatula during the process of introduction. With the assistance of this spatula, it is extremely easy to introduce a wire in an upward and forward direction which penetrates the bone and comes out at the anterior aspect of the acromion. Using this directional approach, it is impossible to injure any articular structure associated with the shoulder joint.

After the wire has been inserted and the entrance and exit wounds properly protected, a small Kirschner spreader is attached and proper tension of the wire established. The spreader should be of a height just adequate to span the rounded tip of the shoulder without contacting the skin. A spreader with any greater height

than this adds to the cumbersome nature of the subsequent dressing.

A plaster of Paris jacket is then applied

After the plaster jacket has been applied, a strip of wood veneer which has been previously soaked in steaming hot



FIG. 4. Roentgenogram showing overriding of the fracture prior to application of extension.



FIG. 5. Kirschner wire in place and correction of overriding under elastic traction.



FIG. 6. Result eight months after injury.

over adequate padding. This jacket must extend from the iliac crest, to which it should be well moulded, and should reach comfortably high into the axillae. Using thin wood veneer strips as a basis, a plaster of Paris arch is articulated to the jacket in such a manner that it spans the point of the shoulder on the affected side, leaving a space adequate to clear the Kirschner stirrup and provide sufficient room to permit elastic extension to be applied to the stirrup. This arch should so clear the shoulder as to enable the surgeon to apply the traction in the indicated direction, that is outward, upward and slightly backward.

water to secure flexibility, is cut to such a length that when arched over the shoulder from the anterior aspect of the jacket to its posterior aspect, it will provide the desired clearance of the stirrup. The strip may be made of multiple layers of the veneer and should be about 1 inch in width. A wrapping of plaster of Paris bandages is applied over the veneer strip, and it is then anchored to the jacket in the proper position with plaster bandages. These are also used to build up the thickness of the arch to a strength adequate to survive any possible stresses it may encounter during the period of treatment. A study of the

illustrations will help to clarify the construction of this arch.

Traction is applied between the arch and the Kirschner spreader by means of rubber bands. The number of rubber bands required will vary of course with the thickness of the bands, the amount of tension applied to each band, and with the size, weight, and muscular development of the patient. The precise amount of traction can be determined by the reduction of the overriding as judged from digital inspection of the fracture, fluoroscopic examination and x-ray films. This type of traction was found to be entirely adequate and sufficiently constant to maintain the normal length of the clavicle throughout treatment.

#### CASE REPORT

E. M., age 17, was admitted to Lenox Hill Hospital February 10th, 1938 with a fracture of the right clavicle. He had fallen on the street, striking the ground with the right shoulder, but did not come to the hospital for treatment until two days later. During the intervening period he was without medical attention. Due to birth injury, the patient had always been mentally backward.

Pain and disability of the right shoulder were present and this shoulder was about 2 cm. below the level of the left and more medially placed. The right clavicle presented a palpable irregularity at about its mid-portion with obvious deformity. This area was tender to pressure, and x-rays revealed a fracture of the middle third of the clavicle with the medial fragment overriding the lateral fragment approximately 1 inch.

On account of the mental status of this patient and the obvious impossibility of preventing him from meddling with any apparatus which might be applied, we decided to attempt reduction by means of skeletal traction. This was done in the manner above described. After the Kirschner spreader had been fastened with adequate tension, elastic traction was instituted by means of rubber bands exerting traction upon the clavicle in an upward, outward and slightly backward direction.

The patient returned from the operating room in a wheelchair. He had no discomfort and was ambulatory in the ward, but his mental condition made him unruly and difficult to

discipline. On February 14 the fracture site was no longer palpable as an irregularity along the continuity of the clavicle. However, the patient insisted on playing with the apparatus and introduced a superficial infection at the posterior site of the entrance of the wire which necessitated its removal on February 22. At this time union had obviously progressed to a sufficient degree to prevent any recurrence of displacement. No false motion was detected, and the patient was discharged on February 25, wearing a dressing over the puncture wounds which had already healed. He was seen subsequently on two occasions in the out-patient department. On October 4, 1938 the shoulders were symmetrical as judged by height and distance of the acromion tips from the sternal notch. There was no deformity of the clavicle evident on inspection. X-rays showed firm union with a fusiform callus and preservation of the normal clavicular curve without overriding. The scars of the Kirschner wire wounds are insignificant and scarcely noticeable.

#### COMMENT

This is admittedly a report of a single case, but is presented in order to demonstrate the feasibility of this approach to the solution of the problem of correcting overriding in fractures of the clavicle. The mechanics of the method are simple and applicable by any surgeon who has the facilities for the introduction of a Kirschner wire.

The results in this first case might have been slightly better had we been able to maintain traction over a longer period of time. Inasmuch as the patient was a mental defective and evidently was himself the cause of the superficial infection which ensued, we feel that this complication is one which is not to be anticipated in the average case. The infection subsided immediately upon withdrawal of the wire.

From the experience gained in this case, we feel justified in recommending the method of skeletal traction in cases of overriding fracture of the clavicle, in which it is deemed desirable to overcome the cosmetic blemish of the clavicular irregularity without adding the equally undesirable blemish of an operative scar.



# OSTEOGENIC SARCOMA OF THE THYROID GLAND\*

## REPORT OF A CASE

MARTIN BATTS, JR., M.D.

ANN ARBOR, MICHIGAN

**O**STEOGENIC sarcoma of the thyroid is an extremely rare lesion. In 1935 Broders and Pemberton reported one case which was the first of its kind observed in the course of a pathologic examination of approximately 40,000 thyroid glands. A survey of the literature at that time revealed only six previously reported cases by Foerster, Pick, Funkenstein, Chavannay and Nadal-Pierre, and Solaro. The following is a report of an additional case.

### CASE REPORT

A. J., a 71-year-old female, entered the University Hospital on November 21, 1933 with the complaint of a swelling in the neck. At the age of 19 years the patient had noted a nodule on the left side of the neck, which was not painful and not tender. At the age of 45 years this nodule began to increase in size, and at the time of admission was approximately the size of a baseball. During the six months previous to admission the patient had noted nervousness, anorexia, increased perspiration, palpitation, frequent choking sensations, dyspnea on exertion, and swelling of the ankles. She had lost 15 pounds in weight in six months.

Physical examination revealed a senile, white female, not acutely ill, but showing evidence of recent weight loss. There was complete blindness of the left eye, enophthalmos, and an old traumatic scar of the cornea and iris. The mouth was edentulous. There was a large, nodular tumor 7 cm. in diameter, which seemed to involve the entire thyroid. This tumor was hard in consistency, but there were scattered areas which felt cystic. The trachea was not palpable. There was no bruit or thrill over the tumor. The heart was moderately enlarged and there was an occasional extrasystole. There were a few crackling râles at the right lung base. There was evidence of generalized

peripheral sclerosis. The blood pressure was 188/96. There was slight pitting edema of the ankles.

Examination of the blood revealed a hemoglobin of 68 per cent, a red blood cell count of 4,100,000 per cu. mm., and a white blood cell count of 7,850 per cu. mm. The Kahn test for syphilis was negative. The urine examination was negative. X-ray examination of the chest revealed a large, round mass in the base of the neck compressing the trachea and reducing its lumen to about one-quarter of its former width; scattered calcium deposits were noted throughout the anterior position of the tumor. The basal metabolic rate was plus 31 per cent, with a pulse rate of 80 per minute. The electrocardiogram was normal. Laryngoscopic examination was negative.

A provisional diagnosis of adenomatous goiter with hyperthyroidism and questionable malignant degeneration was made. On November 29, a subtotal thyroidectomy was done by Dr. F. A. Collier under local novocaine anesthesia. The pathological diagnosis rendered by Dr. C. V. Weller was: "This is a very unusual neoplasm. It is a supporting tissue tumor which forms osteoid tissue and bone, but which is arising in an old thyroid adenoma with remains of the old glandular structures still present. The neoplasm can be designated a spindle-celled osteoid-osteo-fibrosarcoma. Some areas show giant cells of the type found in benign bone tumors. Early metastases from this neoplasm are not anticipated."

The immediate postoperative condition was good. Preoperatively the patient had been placed on Lugol's solution, which was continued after operation. On the first postoperative day there was a fever of 102 degrees. Thereafter the patient continued to run an afternoon fever which remained unexplained until the eighth postoperative day when fluctuation was noted in the left angle of the wound. Incision was done, and drainage of seropurulent material was carried out, after which

\* From the Department of Surgery, University of Michigan.

the wound healed. The patient was discharged on the eighteenth postoperative day with instructions to continue with the Lugol's solution.

indistinguishable from those of benign osteoblasts, followed by the formation of osteoid tissue and true bone.

The above explanation is in full accord

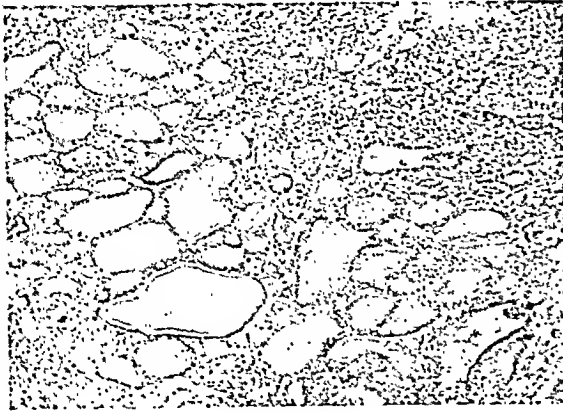


FIG. 1.

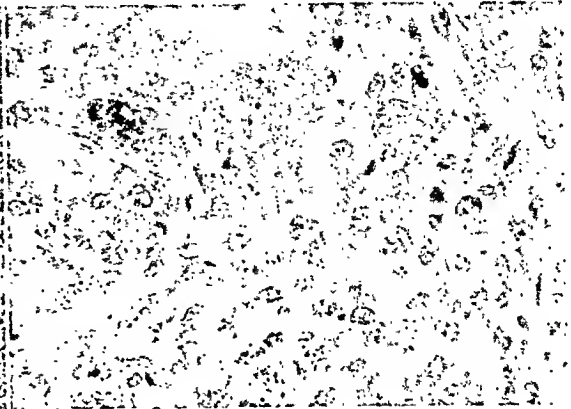


FIG. 2.

Following discharge the patient was treated with heavy doses of x-ray radiation. She continued to show signs and symptoms of myocardial insufficiency, and on March 23, 1934 died of cardiac failure. An autopsy was not obtained.

with the cellular or classical theory of bone formation, which attributes to the osteoblast the important rôle in the formation of bone. In this connection it is interesting to note the newer theories of bone formation. Leriche and Policard expressed the view



FIG. 3.

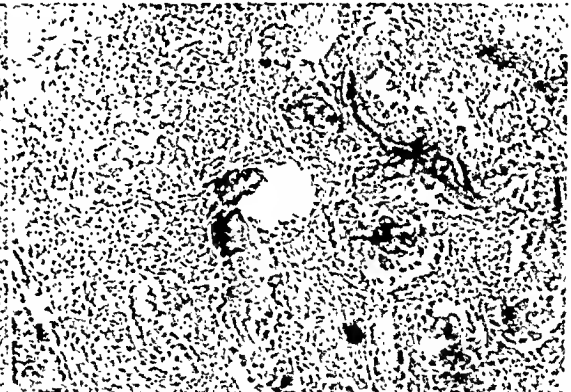


FIG. 4.

To account for the occurrence of an osteogenic sarcoma in such an unusual location, Broders and Pemberton decided that the sarcoma arose from the stroma of the thyroid gland by dedifferentiation, or anaplasia, of fibroblasts. This was substantially the same concept held by Foerster and Solaro. They further believed that the bone was a direct descendant of sarcomatous tissue, as held by Pick, Funkinstein, and Solaro; the sarcoma cells produced sarcomatous osteoblasts, which in turn produced osteoblasts that were

that formation of bone is the result of a metaplastic change in the connective fundamental substance; this osseous metaplasia can occur in all types of connective tissue; the cells themselves do not play the part classically attributed to them, that is to say, osteoblasts do not secrete true osseous substance between the cells; rather, the osseous transformation of connective tissue is a phenomenon independent of all cellular action, and is an interstitial and humoral process. The work of Huggins in which heterotopic ossification was produced by

transplants of the epithelium of the urinary bladder in the abdominal wall seems to support the latter theory. Perhaps this theory also offers the best explanation for the occurrence of an osteogenic sarcoma of the thyroid gland.

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As a rule, a sarcoma of the stomach, where its surface impinges on the lumen, shows an excavated ulcer with undermined edges. Actually many cases of sarcoma of the stomach have been diagnosed under x-rays as chronic ulcer.

From—"Surgery of the Alimentary Tract" by Devine (Williams & Wilkins Company).

# PHLEGMONOUS PROCTITIS

## REPORT OF A CASE

DAVID N. YAKER, M.D.

Attending Proctologist, Cedars of Lebanon Hospital

LOS ANGELES, CALIFORNIA

THE usual rectal complications following pregnancy are hemorrhoids of all kinds, fissures, abscesses; the more serious difficulties are complete tears, especially those with destruction of part of the sphincter mechanism. Several cases of rupture of the rectum following labor have been reported, all of these occurring in patients who had a preëxisting stricture of the rectum.

Phlegmonous proctitis can be brought about by the introduction of chemical irritants into the rectum, or can be produced by a hot enema, or a long protracted hard labor. These are probably etiologic factors in the present case. The patient was given paraldehyde per rectum for analgesic purposes at the onset of labor; several hours later it was repeated. On the tenth day postpartum the patient was given a soapsuds enema, and, at that time, complained that it felt warm; the day following she complained of pain in the coccygeal region which continued; there was no rise in temperature, no diarrhea. On the fourteenth day she returned home and on that evening began to show symptoms of a severe proctitis. In view of the fact that the symptoms came on fourteen days after the introduction of paraldehyde and fourteen days after labor, and almost immediately after the hot enema, it is the opinion of the author that the latter was the most likely etiologic factor.

### CASE REPORT

Mrs. L. C., aged 28, primipara, reported a negative past history, with the exception of childhood diseases. She had been given some injections for hemorrhoids in 1934.

Labor started at 1:00 A.M. on November 5, 1935, and ended at 5:24 P.M. that same day. For

analgesia she was given a hypodermic injection of  $\frac{1}{3}$  gr. pantopon and  $\frac{1}{200}$  gr. scopolamine; also 3 gr. sodium amytal and nembutal. At 10:00 A.M. she was given 4 drams paraldehyde in 3 ounces of olive oil, and this was repeated at 12:45 P.M. At 5:24 P.M. she was delivered after median episiotomy and application of low forceps, nitrous oxide and ether being given by inhalation.

The postpartum course was normal; on November 7, 1935, her bowels moved; she was troubled by external hemorrhoids to which nupercaine ointment was applied daily. On November 12, 1935, she was given a soapsuds enema which produced fair results. On November 13, 1935, her bowels moved, but her hemorrhoids gave her considerable pain which was somewhat alleviated by nupercaine ointment. On the morning of November 14, 1935, she was given a soapsuds enema preparatory to surgery for cervical repair; at the time of the enema she reported to her obstetrician that the fluid felt rather warm. On November 15, 1935, she began to complain of pain in the region of the coccyx, and for this the infra-red ray was applied. On November 16, 1935, she was given a soapsuds enema with excellent results, and again the infra-red was applied to the lower back. On November 17, 1935, she had a normal bowel movement and a hot water bag was placed over the region of the coccyx to relieve her pain. On November 18, 1935, the patient felt quite well, and was taken home later in the day.

After returning home the patient had several bowel movements, accompanied by a purulent discharge and some pain. The author first saw the patient that evening at her home and found her rather nervous and upset and in bed. A large piece of sloughing mucous membrane, at least 2 inches in width and 6 inches in length was protruding from the anus; further examination revealed more of this mucous membrane slough within the anal canal and rectum. The slough protruding from the anus was excised. On the morning of November 19, 1935, there

was another equally large piece of sloughing mucous membrane protruding from the anus, and this was excised. During the day she passed another slough 5 inches in length and 2 inches in width; that evening a speculum was introduced, and an extremely raw surface was seen in the upper part of the rectum. Further examination was not deemed advisable at this time. Temperature and pulse were normal all day.

On November 20, 1935, the rectum was examined and found to be very raw and denuded of its mucous membrane; there was some purulent discharge from the anus. Two ounces of 1½ per cent mercurchrome were instilled into the rectum and the patient was told to take one ounce of mineral oil three times daily. On November 21, 1935, there were two small bowel movements with some purulent discharge. The patient complained of her hemorrhoids, but, due to the severity of her proctitis, nothing was done for this for the time being.

On November 22, 1935, the patient stated she had a soft liquid bowel movement. Examination revealed very little purulent discharge, but the entire rectum was raw and denuded. On November 24, 1935, patient had a very good day, with the exception of some rectal bleeding. The following day she was quite well, had a bowel movement with no bleeding, and then passed several clots and some fresh blood. At 5:00 P.M. she was still bleeding and examination revealed the rectum filled with clots which were removed. Bleeding was checked by packing the rectum, especially the raw bleeding surface, with vaseline gauze. There being no further bleeding, the packing was removed the next day. From then on progress was very good; the wound began to heal and the patient began to feel better; she was given 2 ounces of mineral oil per rectum every night as a retention enema. A high caloric, low residue diet produced rather small liquid bowel movements.

Due to the acuteness and severity of her condition the patient was not sigmoidoscoped until December 4, 1935, at which time examination revealed that a stricture of the rectum had developed 10 cm. above the anus, through which the small ¾ inch sigmoidoscope could not be passed. Dilatation of the rectum was begun December 5, 1935, Hegar dilators being

used. The No. 8 dilator was used that day and dilatation was repeated every fourth day.

On June 3, 1936, a No. 22 dilator was passed and at the same examination a ¾ inch sigmoidoscope was passed beyond the stricture area which was about 1 inch in length and completely encircled the bowel wall. Much granulation tissue could be seen in the stricture area, which bled rather easily. Dilatation was continued every fourth day and the patient continued to improve. Bowel function was quite normal, with mineral oil being used as a lubricant.

On June 20, 1936, a barium enema showed a definite constriction at the midpoint of the rectum, which, however, was regular and did not bar easy access of the opaque meal; there was some lack of haustration in the descending colon.

Gradually dilatation was brought about, and on December 28, 1936, the large No. 22 dilator was used with no difficulty; the sigmoidoscope was easily passed and no pathology was seen with the exception of a slight constriction at the site of injury. The patient thereafter remained well.

#### DISCUSSION

According to Frederick Wallis<sup>1</sup> one of the causes of stricture of the rectum may be attributed to a long protracted labor in which the child's head becomes jammed in the pelvis for some hours. By direct pressure it may cause ultimate destruction of an area of mucous membrane, which generally separates, and, due to constant exposure to fecal material, becomes septic. This may be the origin of progressive ulceration and stricture formation. However, if this were true, many cases of rectal ulceration and stricture formation would be seen following these long protracted labors. The rectum is movable and can be easily accommodated along the sides of the sacral promontory in an already crowded pelvis. Further, in the case under discussion, the patient, a primipara, was in labor for sixteen hours which is, according to Williams,<sup>2</sup> two hours less than the normal for a primipara. Further, in view of the fact that the symptoms in this case did not come on until fourteen days following

delivery, this etiologic factor can be eliminated.

The author knows of two cases in which there was a pronounced local irritation and generalized rash following the application of nupercaine to the anal region. In this case the drug was used to allay the soreness of hemorrhoids following delivery, but at no time were there any signs of local irritation.

Paraldehyde has been used per rectum for analgesic purposes with no harmful effects either locally or generally. Kane and Roth<sup>3</sup> report ninety-one cases with no ill effects; Rosenfield<sup>4</sup> used it in 400 cases with no harm; Parker<sup>5</sup> has used it effectively with no bad results and reports a case in which a patient received five rectal injections, one every five hours and forty-five minutes, with no injury to the patient; Colvin and Bartholomew<sup>6</sup> report one hundred cases with no ill effects; Kane and Roth<sup>7</sup> in 1936 reported a group of cases with no ill effect of heart, kidney, lungs, liver, respiratory center and bowel. Further, the onset of symptoms fourteen days following the use of paraldehyde makes the author believe that this drug played no part in the production of the symptoms.

In view of the fact that the patient complained of an enema being too hot, and in view of the fact that the symptoms (pain over the region of the coccyx, tenesmus and diarrhea) arose four days later when sloughing began, it is the opinion of the author that the hot enema, given on the tenth day, preparatory to surgery, was the primary etiologic factor in this case. A soapsuds enema in itself is quite irritating to the bowel, as evidenced by the great amount of mucus that is excreted by the bowel following it. It is the opinion of the author that the pathology in this case which brought about a sloughing of the

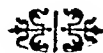
mucous membrane of the rectum can be compared to that of a third degree burn. At a meeting of the North of England Obstetrical and Gynecological Society,<sup>8</sup> several cases were reported of more extensive rectal injury following the use of hot enemas postpartum, and Mr. Kelly, in particular, reported a case in which there was a sloughing of the mucous membrane of the rectum and vaginal wall and the prolapse of gangrenous loops of tissue out of the cavity, closely resembling coils of small gut.

#### SUMMARY

A case of phlegmonous proctitis apparently brought on by a warm enema has here been presented. Due to the great amount of sloughing stricture formation followed. With very conservative treatment, after the acuteness of the condition had subsided, a good curative result was obtained, with almost complete dilatation of the bowels and well functioning rectosigmoid.

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# NEW INSTRUMENTS

## AN INTESTINAL HOLDING CLAMP\*

ROY D. McCLURE, M.D.

Surgeon-in-Chief, Henry Ford Hospital

DETROIT, MICHIGAN

IT is frequently desirable to elevate a segment of the intestinal tract. The usual plan is to use a clamp with

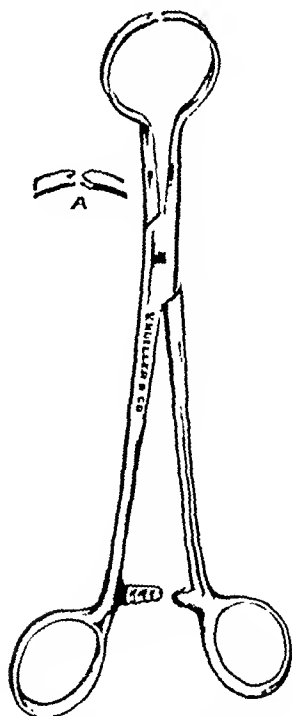


FIG. 1. Ring clamp for holding a segment of intestine.

fenestrated or rubber covered blades. The application of these clamps is a maneuver that requires a good deal of judgment, for, if too much pressure is exerted, some damage of the intestinal wall will occur, and if too little, the instrument will slip.

The clamp here presented and illustrated has been found useful in overcoming these

difficulties. It is simply an adaptation of the principle of the ring clamp. This ring has a diameter of 2.7 cm. which is of sufficient size to encircle the colon. The jaws are of the interlocking, rat-toothed type. The over-all length of the clamp is 19.5 cm.

*Method of Use.* The mesentery of the segment of intestine which the surgeon desires to control is pierced in an avascular area at the bowel margin with a pointed instrument such as the tip of a Kelley artery clamp. The ring clamp is then applied in such a manner as to encircle the bowel, perhaps best by slipping a fingertip through the opening just made by the artery clamp through the mesentery, placing a tip of the opened clamp jaw against the glove; the finger is slowly withdrawn with the tip of the clamp blade following until all danger of scraping the gut is over. The clamp is then closed. The jaws of the clamp meet and interlock through the mesenteric opening. Adequate control of this isolated area of intestine is now possible. There are many situations in intestinal surgery where this clamp has been found exceedingly useful, but its chief value is in control of the mobilized duodenum or pyloric end of the stomach before and during application of crushing clamps prior to section of this organ in gastric resection.

The utility of this clamp is confined to its holding properties, for it does not prevent the passage of intestinal contents.

\* From the Department of General Surgery, Henry Ford Hospital, Detroit, Michigan.

# A NEW TYPE OF TISSUE FORCEPS\*

JAMES BARRETT BROWN, M.D., F.A.C.S.

ST. LOUIS, MISSOURI

THE usual type of tissue forceps with teeth across the end often will not grasp easily tags of tissue, and, if the is that in work in cavities where the grasping of a needle is difficult, this forceps will grasp and steady the needle until a locked



FIG. 1. Tissue forceps with multiple teeth running up the shank instead of across the end. A wider area of tissue is grasped and held more securely with less pressure necessary on each tooth and, therefore, less trauma to the tissue. The round insert does not depict the small individual teeth as clearly as they are on the forceps. (*Arch. Surg.*, June, 1940.)

piece happens to be bone or cartilage, it will invariably slip out of the teeth. When repairing cleft palates or doing other work in the mouth, this is especially annoying. The forceps illustrated was designed to grasp these small bits of tissue.

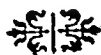
Its essential distinguishing feature is that the teeth run up the shank rather than across the end; there are three small interlocking teeth instead of the usual two on one side and one on the other. A wider area may be grasped and held more firmly, but with less pressure and thereby less trauma by the individual teeth. Another advantage

forceps can be put on it for removal; if the tissue is soft, the forceps is all that is necessary for withdrawal.

After using the forceps originally in the mouth with satisfaction, they were found to be helpful in other work and many times in the approximation of deep tissues and of skin; they have also been used in gynecological work with some enthusiasm.

Since the teeth run up the forceps, the grasp is somewhat sideways, and, for picking up edges at right angle or perpendicular to the incision, the small end tooth forceps may be preferable.

\* From the Department of Surgery, Washington University School of Medicine, St. Louis.





# NEW RECTAL SCISSORS\*

DAVID MILLER, M.D.

Instructor in Proctology, College of Medical Evangelists

LOS ANGELES, CALIFORNIA

IN the practice of proctology, in both hospital and office, the use of a scissors through an anoscope is often required. cauterizing solutions are not effective since they merely cauterize the surface so that too frequent applications are required. The



FIG. 1. Lateral view of scissors showing approximate 45 degree angle near middle of shaft.

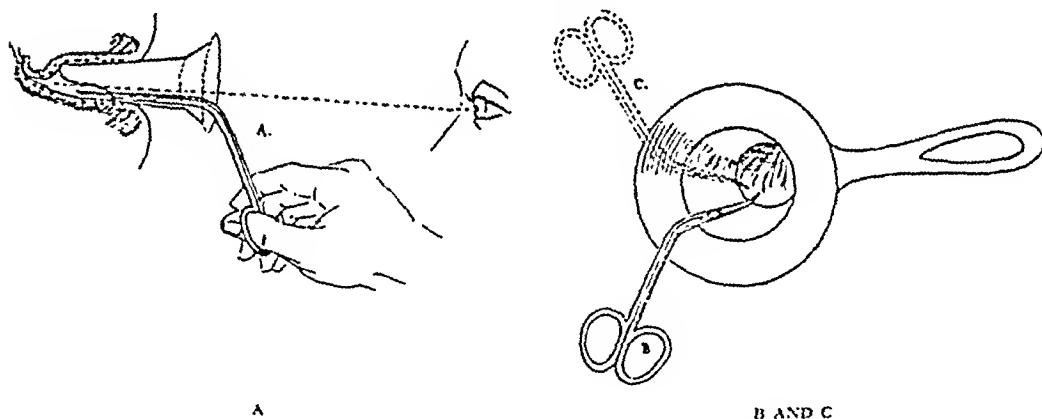


FIG. 2. A, showing the scissors inserted through the anoscope in cutting position and an unobstructed view. B and C, showing the scissors inserted through anoscope in other cutting positions and unobstructed views.

The most common instance is in the post-operative care following surgery of the rectum.

Ten days to two weeks after operation observation through an anoscope frequently reveals varying amounts of excess granulation tissue which must be removed for proper and smooth healing. Varying strengths of silver nitrate and other

action of these various solutions, even when carefully neutralized and when adjacent tissue is protected, cannot be perfectly confined to one area. The liquid spreads and thus causes deleterious effects and much prolonged anal discomfort.

The most effective treatment is excision of the excess tissue. Since no sensory nerves are present, the tissue can be excised pain-

\* From the Department of Proctology, College of Medical Evangelists. Read before the Proctologic Staffs of the White Memorial and the Los Angeles County General Hospitals.

lessly by means of a scissors through an anoscope. With a straight or double curved scissors the job is done with difficulty if at all, since the operator's hand and the finger grips of the scissors are constantly in the line of vision. If the operator is successful in manipulating the scissors in such a way that the hand is not in the line of vision he will find that the light directed into the rectum through the anoscope is obstructed by some part of the scissors. Cutting has to be done almost entirely by sense of touch and in the dark.

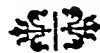
In an attempt to simplify and facilitate the performance of this technical procedure a new type of rectal scissors\* has been devised. The scissors are similar to the conventional type, differing mainly in the construction of the handle which forms an angle of approximately 45 degrees near the middle of the shaft. (Fig. 1.) When the blades of the scissors are inserted through the scope and placed in the cutting position, the finger grips and the operator's hand are not in the line of vision and no part of the scissors blocks the path of light.

\*These scissors are manufactured by J. Sklar Manufacturing Company, Long Island City, N. Y.

Thus an unobstructed view with proper lighting is obtained no matter in which quadrant of the canal the procedure is to be carried out. Figure 2 shows the scissors inserted through the anoscope with the blades in the cutting position and an unobstructed view.

Other changes from the ordinary rectal scissors have been made: the tips of the cutting blades are not sharply pointed, but are barely blunted so that if the points accidentally touch adjacent tissue they will not puncture, but will slide off. Yet the tip is sufficiently pointed so that it can be used for cutting; the cutting edges of the blades are serrated so that the tissue will not slip out when the blades are closed. (The serrated edge is used on several other types of scissors now on the market.) The curve of the cutting blades is far enough from a straight line so that there is just sufficient curve to conform with the slight angle of the tissues. Thus the tips of the blades can cut without great elevation of the handle.

The angled handle and the very slight curve of the blades of the scissors allow for convenience and relative ease in excising tissue from difficult areas and in deep wounds.



## BOOK REVIEWS

**CLINICAL ROENTGENOLOGY OF THE ALIMENTARY TRACT.** By Jacob Buckstein, M.D. Philadelphia, 1940. W. B. Saunders Company. Price \$10.00.

The author in his preface says, "Roentgenography has today become so essential a procedure in the diagnosis of lesions of the alimentary tract that a knowledge of its potentialities should well form part of the armamentarium of every practitioner in the field of medicine and surgery." Inasmuch as it has been Dr. Buckstein's privilege for more than twenty years to see (in Bellevue Hospital, New York) a vast amount of material dealing with the alimentary tract from the roentgenologic, operative and postoperative viewpoints, he has presented material as examples of both normal and pathologic conditions for portrayal in the pages of his book. And he has done a tip-top job. The book is well written and understandable; the 525 illustrations are clear and really illustrate, and there is a bibliographical and subject index. Surgeon, gastroenterologist and internist will find this work interesting and instructive.

**ORTHOPEDIC OPERATIONS.** By Arthur Steindler, M.D. Springfield, 1940. Charles C. Thomas. Price \$9.00.

The author of this work needs no introduction to the surgical fraternity of America. He is preeminent in his field, that of orthopedic surgery, and his book echoes or mirrors the knowledge Dr. Steindler has acquired, sifted and evaluated. Therefore, he has written a preeminently practical book, a book that answers such questions as How, When, With What Results? Unlike the usual book on this subject, *Orthopedic Operations* lays special stress upon the indications and end results in specific orthopedic conditions. Much information (bad procedures have not been introduced) has been put into its 766 pages, which also contain 865 illustrations on 322 figures, chapter bibliographies, 1756 subject index and 1469 author index references. We agree with the statement, "Steindler's new book guides the operator quickly to the exact practical procedure which is best fitted to meet each precise clinical situation."

**TREATMENT OF WAR WOUNDS AND FRACTURES WITH SPECIAL REFERENCE TO THE CLOSED METHOD AS USED IN THE WAR IN SPAIN.** By J. Trueta, M.D. With a Foreword by H. Winnett Orr, M.D. New York, 1940. Paul B. Hoeber, Inc. Price \$2.50.

The author tells us that his work is "an amplification of a small manual which was published during the war in Spain, first in Catalan and later in Spanish. The original text was written under war conditions." We are told that open fractures produced in road accidents or in industry do not differ essentially from those produced by aerial bombs or falling masonry. Also, that the fundamental principles of treatment are the same whatever the cause. Dr. Orr, in his Foreword states, "It has been demonstrated now by many surgeons that drainage, skeletal fixation in plaster of Paris casts, and protection against the trauma and re-infection caused by frequent dressings will enable a high percentage of these patients to recover. Dr. Trueta has brought this lesson home to us by a most convincing demonstration under military conditions." This tells what this small book of 146 pages covers. There are 48 illustrations, a bibliography and an index. Unless familiar in every detail with this method we urge every surgeon, especially those dealing with fractures and traumatic injuries, to possess this book.

**A TEXT-BOOK OF GYNAECOLOGY.** By James Young, M.D. Fifth Edition, Revised. London, 1939. Adam & Charles Black. Price \$5.00.

*A Text-Book of Gynaecology* first appeared in 1921 and now is offered in its fifth edition. This speaks for itself. Although it has been revised and certain parts rewritten, this edition differs from the former in having added the important contribution of sex endocrinology, a consideration of the synthetic estrogens and the appraisal of their clinical value by The Therapeutic Trials Committee of the Medical Research Council. For anyone who wishes to get or keep abreast of modern gynecological teaching this work, containing 425 pages, and 226 illustrations, is recommended.





OSLER AT OLD BLOCKLEY

by Dean Cornwell, N.A.

# The American Journal of Surgery

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A PRACTICAL JOURNAL BUILT ON MERIT

## EDITORIALS

### "OSLER AT OLD BLOCKLEY"

DEAN CORNELL, noted American illustrator and mural painter, has finished the second of his proposed series of paintings of notable figures in American medicine. It is called "Osler at Old Blockley," and a reproduction is shown in the Frontispiece of this issue of the Journal.

This painting was first shown on the occasion of the dedication, on June eighth, of the Osler Memorial Building at The Philadelphia General Hospital. The old autopsy house was restored "As a Memorial to William Osler, M.D." by John Wyeth & Brother, Inc., of Philadelphia.

Osler came to Philadelphia as professor of clinical medicine early in October, 1884. He remained there for about five years. During that time Osler left an imprint so deep that years later those who worked with and under him resolved to build a shrine to his memory of the old "Post House" which was the scene of "The Great Physician's" inspiring teaching and work. Finally, this became a reality due to the timely assistance and generosity of John Wyeth & Brother, Inc.

Dean Cornell's painting depicts Osler addressing a group of residents at the bedside of a patient on the lawn under a large tree. The "Post House," where the painting will eventually find a permanent

home, is shown in the background. Artist Cornell spent many months in historical research in preparation for the painting. The uniforms of the students and nurses were carefully authenticated. The grey pitcher, seen in the foreground, and other objects depicted were painted from originals of the period. The artist called upon many authorities for advice and criticism. We are told that one of the last conversations which the late Harvey Cushing had with persons, not members of his immediate household, was with Mr. Cornell concerning this contribution to American medicine.

The first painting of the series was "Beaumont and St. Martin." We told our readers about this in "The Artist Views American Medical Pioneers" (March, 1939). It has been exhibited at twenty-six medical schools during the past year and a half. It is still on tour as will be "Osler at Old Blockley."

These are truly epic works of art. We prize no end the framed reproductions of these paintings which John Wyeth & Brother so kindly presented to us. And we await with keen anticipation the next painting in the series by Dean Cornell who so ably has caught the spirit of the times and scenes depicted.

T. S. W.

## DO THIS NOW

EARLY in July questionnaires from the A.M.A. began to reach doctors relating to classification of physicians for defense.

It goes without saying that this is a matter that should be answered at ONCE . . . IMMEDIATELY. When you re-

ceive this questionnaire, do not put it aside but fill it out without delay and return it to the A.M.A. The tabulation of the information received will take some time.

It is a professional and civic duty that this matter be awarded FIRST consideration in the day's business.



## HOWARD L. UPDEGRAFF

HOWARD L. UPDEGRAFF, of Hollywood, California, widely known for his work in plastic and reconstructive surgery, died on August 8, at the age of forty-four years.

Dr. Updegraff was an associate editor of The American Journal of Surgery and gave valuable assistance in the form of constructive criticism, editorials and contributions. One of the last articles he

wrote, entitled "Wound Closure, with Particular Reference to the Avoidance of Scars," will appear in our December issue.

Although young in years he played an important role in his chosen field and the horizon of his future accomplishments seemed far away. He was a real friend of the publisher and editor and they and his many friends regret this loss. All who knew him will miss him in the years to come.

# ORIGINAL ARTICLES

## FURTHER OBSERVATIONS ON THE TREATMENT OF BURSITIS OF THE SHOULDER \*

ROBERT LEE PATTERSON, JR., M.D. AND RUSSEL H. PATTERSON, M.D.

NEW YORK CITY

IN reviewing the records of 104 cases of painful shoulders treated by us, the following diagnoses were found:

	No. of Cases
Bursitis.....	70
With calcification in the bursa or tendons....	55
Without calcification.....	15
Periarticular inflammation.....	15
Sprain or subluxation.....	8
Arthritis.....	6
Rupture of the supraspinatus tendon.....	3
Congenital deformity.....	2

If we limit ourselves to the consideration of inflammation of the tendons about the shoulder and their overlying structure, the bursa, 80 per cent of these painful shoulders will be included.

Two years ago, one of us (R. L. P., Jr.) and Dr. William Darrach<sup>1</sup> reported sixty-three cases of bursitis of the shoulder treated by needle irrigation. According to the technique described, (Fig. 1) the patient is placed face upwards on a table. The skin over the affected area is prepared with iodine. One per cent novocaine is injected with a hypodermic needle into two areas: the first, anteriorly two fingerbreadths lateral to and on the same horizontal line with the coracoid process; the second, posteriorly about one fingerbreadth below the outer tip of the acromion just over the greater tuberosity of the humerus. After the skin is anesthetized an 18 gauge, 2½ inch needle is inserted into each area and is pushed gently down about ½ inch. If the bone is felt the needle is withdrawn about ⅛ inch. Here the needles should be in the bursa. Four to 10 c.c. of novocaine are used

to get the flow between the needles started and 40 to 60 c.c. of normal saline are used to wash the bursa clean. The needles are removed and a dressing applied. Since this technique was reported, we have continued to use it. We are convinced that the procedure has a definite place in the treatment of bursitis because it gives in most cases a quick relief from severe pain and shortens the period of economic disability. With increasing experience, we have reached certain further conclusions.

*Anatomy.* The subdeltoid or subacromial bursa lies between the acromion and the deltoid muscle above, and the greater tuberosity of the humerus and the distal portion of the supraspinatus tendon below. It does not connect with the shoulder joint except when the supraspinatus tendon is torn.<sup>2</sup> Many of the bursae have septa dividing them into compartments. The function of this bursa is to prevent friction and to permit movement of the greater tuberosity in and out from under the acromion in motions of abduction and rotation. Any disease or injury which produces changes in this bursa disturbs its function and gives symptoms of bursitis, as for example: productive changes about the acromial process and tuberosity of the humerus incidental to arthritis; hemorrhage due to contusions about the shoulder; injuries of the tendons or capsule which actually tear the walls of the bursal sac, or repeated friction from calcium deposits in adjacent tendons.

*Bursitis—a Secondary Disease.* Primary inflammation, i.e., bacterial infection, does

\* Read before the Orthopedic Section, New York Academy of Medicine, February 17, 1939.



occur. Hitzrot<sup>3</sup> reported three such cases. However, in none of our cases have we seen an infected bursa nor have we had an infec-

foundly affects that weakest and most susceptible structure about the shoulder, the supraspinatus tendon, whose function

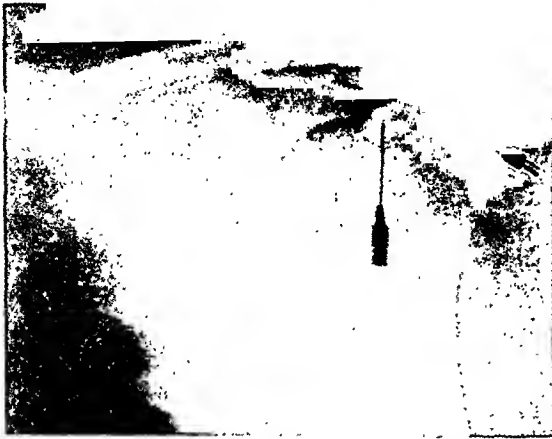


FIG. 1A. Needles shown inserted into calcium deposit in subacromial bursa. (From Darrach and Patterson.)



FIG. 1B. The same shoulder as in Figure 1A following irrigation. (From Darrach and Patterson.)

tion following irrigation or operation. It is therefore our belief that the common form of bursitis is not a primary disease but a secondary reaction in the walls of the bursa to some injury or pathology of the surrounding structures, especially those underlying the floor of the sac. Philip Wilson<sup>4</sup> has stated that the "all-embracing and commonly made diagnosis of subacromial or subdeltoid bursitis is usually inaccurate and rarely justified . . . that the great majority of the affections of the bursa are secondary to some primary lesion in one of the neighboring structures." Codman<sup>5</sup> since 1904 has continually stressed this important fact. Harbin<sup>6</sup> in 1929 brought out the importance of being able to distinguish a lesion of the tendon from one of the bursa.

**Calcium Deposits.** In 78 per cent of our cases of bursitis calcium deposits were proved either in the bursa or in the tendon. When there is a definite history of injury sufficient to produce inflammatory changes in the tendons and capsule about the shoulder, we can readily account for the steps leading up to a calcium deposition. However, when there is no history of injury and yet calcification is present, it is difficult to account for what has happened. Our opinion is that wear and tear of usage pro-

it is to anchor the head of the humerus against the glenoid so abduction can take place.<sup>7</sup> When man assumed the orthograde position, the additional weight of the arm made this function more difficult. The tendon has practically no blood supply and hence does not stand usage well. Over a period of years this process of wear and tear takes place, friction from above and below aiding, until calcification appears. This last step, according to Moschcowitz,<sup>8</sup> is nature's attempt to bring about repair in the presence of necrosis and a poor blood supply. Positive proof that this process has occurred is demonstrable by x-ray or by autopsy which, according to Codman,<sup>9</sup> reveals one torn tendon in every five examined.

Calcareous deposits occur not only in the supraspinatus, but also in the tendons of the teres minor, the infraspinatus, and the subscapularis muscles. We have observed and treated them in other parts of the body, such as the subtrochanteric bursa (Fig. 2), the semimembranosis bursa, and the radiohumeral bursa.

The calcareous deposit has been analyzed by several workers with varying results. It is usually reported between 11 per cent and 22 per cent calcium in the dry substance.

Calcium phosphate predominates over the carbonate. There is some magnesium.

These deposits may be present and yet

sometimes shown apparently the same amount of calcium after irrigation as before and yet the patient's symptoms have dis-



FIG. 2A. Represents calcified deposit about left hip. Acute onset with sciatic pain of two days duration. An example of the fact that calcification occurs about joints other than the shoulder.

give no symptoms, or they may slowly disappear over a period of time, whether treated by diathermy, by deep x-ray, or only by rest. The majority, however, remain or gradually increase in size until sudden trauma, sprain, or excessive friction occurs and rupture into the floor of the bursa takes place. Then acute symptoms develop.

An x-ray before irrigation or treatment is recommended, not only to determine the character and extent of the calcium deposit, if present, but also to make sure that some serious pathologic process, such as tuberculosis of the joint or a Brodie's abscess of the neck of the humerus, is not overlooked. However, we no longer make a point of taking an x-ray immediately after irrigation to see if the calcium has been completely washed out. If the patient's symptoms are relieved the presence or absence of calcium is relatively unimportant. A milky fluid, calcium in dilute solution, has been obtained in the irrigation of a bursa after a negative x-ray. We have relieved a patient's symptoms by irrigation without obtaining any demonstrable calcium. X-rays have

appeared. Although we realize that the underlying process of tendinitis with calcification may return or may occur in other tendons about the shoulder and produce another attack of bursitis, we still maintain that, in irrigation, the relief of the acute pain and not the purely mechanical removal of the calcium deposit should be our aim.

*X-ray Technique.* In order not to overlook one of these deposits about the shoulder, we again want to stress the importance of taking x-rays in internal and external rotation. The former is easy since in the acute shoulder the patient's arm is adducted and internally rotated. But it is cruel and often impossible to rotate externally the acute shoulder. Now, as recently recommended by Lewis<sup>10</sup> at the Hospital for the Ruptured and Crippled, an oblique projection is taken. The patient stands with the shoulder against the cassette and the body at an angle of about 30 degrees.

The choice and selection of cases for irrigation is important. If we adhere to our original conclusions that the irrigation method is best for the acute case or the chronic case with an acute exacerbation,

then we can be reasonably sure of the result.

*Technique of Irrigation.* 1. One should



FIG. 2B. The same case as Figure 2A twenty-four hours after irrigation. Calcium has been washed out. Complete relief of symptoms occurred immediately.

not hesitate to administer a general anesthetic, especially to a very sick patient or a very excitable one. We have used general anesthesia in some 2 per cent of our cases.

2. Formerly, regardless of the points of tenderness, we inserted our needles in the position already shown. In the majority of cases the landmarks described will correspond to one of the tender spots. However, if neither of these two spots is the point of maximum tenderness, we now advise the insertion of one needle into the tender area and the second needle into either the front or the side position. Elmslie<sup>11</sup> stated in his excellent article that if a calcified type of lesion is present, a tender spot can always be found. One should not hesitate even to insert three or four needles if a good flow is not obtained between the first two, and if the tender spot has not been relieved.

3. We now think that a full range of motion should be obtained at the time of irrigation. When the needles have been inserted and the bursa washed, we remove the needles and gently put the arm through a full range of external rotation and abduction. If this cannot be done or if the patient complains too much, we reinsert the needles in the shoulder at the site of remaining tender spots. In other words, we are not satisfied until the patient has no pain and a satisfactory range of motion is possible.

*Cases Not to Irrigate.* We advise the irrigation of the acute shoulder, but there are cases of a borderline nature which are difficult. In five types of cases irrigation has been found to be certainly contraindicated:

1. The first type consists of patients with vague complaints of pain and numbness in the shoulder and arm, in whom there is a definite limitation of motion due to soft part contractures. Operative removal of the deposit, followed by manipulation and a long period of exercises has been found more advantageous in such cases.

2. The second type of case in which irrigation is to be avoided is the one with subjective symptoms of a vague nature but with no positive objective findings on examination. As a rule, this patient has had no conservative treatment and usually turns out to have something other than bursitis.

3. Irrigation has proved of little permanent value in cases in which x-rays showed a decreased width of the acromioclavicular joint, with roughening of the under surface of the acromion or of the tip of the tuberosity of the humerus, even though symptoms point to the bursa. By irrigating, we relieve tension in the bursa but do not change the underlying bony pathology. One possible exception to this statement is found in the patient with generalized arthritis who suffers bursal pain secondary to the bony changes. Irrigation produces temporary relief of pain and may help the patient to bear his generalized affliction.

4. There is a large group of cases classified as periarticular inflammation, second

in frequency in our series, which require an entirely different form of treatment. These patients are not usually seen by the specialist in the acute stages but are referred to him after the shoulder has failed to respond to all the routine forms of treatment—baking, massage, diathermy, plaster, injection, etc. Such cases have usually been overtreated and the patients have limited motion, complain of pain at night and on attempting to use the arms, and show atrophy of the deltoid and supraspinatus muscles. The skin over the shoulder has been “cooked” brown. Roentgenograms show only decreased density of bone. Certainly, irrigation of the bursa is not going to produce relief and would only add further strain. We now believe that most of these cases may be diagnosed as periarticular inflammation, i.e., tendinitis, capsulitis, myositis, etc., secondary to some general systemic infection or metabolic disturbance, such as toxemia, arthritis, gout, etc. Dickson and Crosley,<sup>12</sup> who reported 200 such cases, found a definite focus of infection in 176 of them. Out of the 200, 188 cleared up entirely, though it often took from one to six months. Our experience has taught the same.

Because the patient is sick, has a lowered resistance, and is physically tired of both pain and disability, it is imperative that all form of treatment be discontinued for a period of two weeks or longer. A vacation or rest from work is indicated. After this the following routine is recommended:

1. A complete physical examination with the removal of all possible foci of infection should be made and proper medication for sleep, diet, or anemia given.

2. The patient should be told that the process is a long one, often lasting four to six months, that perseverance is necessary, but that the results will be good with proper treatment.

3. Antigravity exercises should be performed regularly and efficiently each day.

4. Failure to respond to exercise after one month of treatment is an indication for admission to a hospital, where manipula-

tion with breaking of adhesions should be performed. At the suggestion of Ober<sup>13</sup> we have injected the bursal region with 150 to 200 c.c. of saline and then manipulated the joint. This technique tends to dilute hemorrhage and to prevent the reforming of adhesions. We have tried it in a small number of cases and have found it to be of value. An abduction splint should immediately be applied and kept on for a period of three weeks. It should be removed daily, however, for exercises. In the average case, unless splinting is done following this treatment, the joint will very quickly “freeze” again.

5. Finally, do not irrigate, manipulate, or operate upon both shoulders at the same time when treating a bilateral shoulder condition. This is extremely important when handling cases of doubtful diagnosis and uncertain etiology.

#### SUMMARY

1. The most common condition found in the painful shoulder is bursitis.

2. Primary bacterial inflammation is rare in subacromial bursae.

3. Subacromial bursitis is nearly always secondary to injury of a neighboring structure.

4. Calcification can be demonstrated in about four out of five cases of bursitis of the shoulder.

5. Calcification in the five main tendons about the shoulder may eventually occur if they have been subjected to wear and tear or repeated small injuries.

6. The severity of the symptoms associated with bursitis is not in proportion to the amount of calcification present.

7. No treatment of a painful shoulder should be undertaken until x-rays have been studied. The oblique projection is strongly recommended.

8. Irrigation of the bursa is indicated in a large majority of acute cases. It is, however, definitely contraindicated in periarticular inflammation and all conditions of doubtful etiology.

9. Both shoulders should never be irrigated, stretched or operated upon at the same time.

10. The irrigation procedure is always best carried out in the hospital.

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# A METHOD FOR PROTECTING THE SKIN IN "WINDOWED" UNPADDED CASTS\*

H. D. COGSWELL, M.D. AND C. A. THOMAS, M.D., F.A.C.S.

TUCSON, ARIZONA

IT is often necessary to cut a window in unpadded plaster of Paris casts to change dressings or relieve pressure.

to describe a method which prevents this condition from occurring.

The unpadded plaster of Paris splint is



FIG. 1. Window in cast with beveled edges shown with removed plug. Although it is not apparent in the photograph, the plug fits accurately into the cast window.



FIG. 2. Window plugged with the plaster mould. It is necessary to encircle this area of the cast with a bandage, as walking loosens a strip of adhesive tape as shown above.

Unless some method is used of replacing the even pressure afforded by the plaster splint, edema will appear with passive congestion of the underlying skin, and pressure necrosis may result. This is especially true when a Böhler's walking cast is being worn. The resulting pain and disability defeat the purpose of a walking cast by discouraging the patient to the point of not walking.

Due to the fact that it is not uncommon to see patients with areas of edematous skin bulging through cast windows, it was thought worth while

applied in the usual manner, and the area to be removed is outlined by an indelible pencil. A window of the proper size is cut, beveling the edges of the cast so that the smallest diameter is on the inner side next to the skin. It is not possible to use the portion removed as a plug for the window, for it is well frayed by the time it has been removed. The beveled edges of the cast are then lined with adhesive tape and the wound covered with five or six thicknesses of gauze. A strip of wet plaster of Paris gauze is wadded and packed into the open-

\* From the Thomas-Davis Clinic.

ing and pressure applied until it hardens. It will be found that the plug of plaster will apply too much pressure to be comfortable, and layers of the gauze may be removed until the patient states that he is comfortable with weight bearing. The patient will rapidly learn how to pad the window and do his own dressing as often as needed. The plug may be shellacked to prevent its being softened by drainage. The tape lining and beveled edges make the plug easy to remove, and it is held by a bandage which envelops this portion of the cast.



THE fate of an injured hand is often decided promptly and permanently by the doctor who renders first treatment. What occurs in the first couple of hours can make the difference between a good or a bad result. From—"Surgery of the Hand" by Couch (University of Toronto Press).

# THE NEWER VENEREAL DISEASES\*†

## THEIR ASSOCIATION AND CONFUSION WITH NEOPLASTIC DISEASE

ROBERT B. GREENBLATT, M.D.

Professor of Experimental Medicine, University of Georgia School of Medicine

AUGUSTA, GEORGIA

IT is well that the agencies of man and of government have shouldered a responsibility to society in educating the public and particularly the physician to the problem of the venereal diseases. With the rapid advance and dissemination of our knowledge, particularly of the so-called newer venereal diseases, many a person with some venereal oddity, unresponsive to therapy, is at once labeled as suffering from granuloma inguinale, lymphogranuloma venereum or gangrenous chancroid with perhaps a superimposed fusospirochetosis. The physician has become so venereal disease-conscious when confronted with some singular genital lesion that he is oblivious to the probability of malignant disease.

The purpose of this paper is to draw attention to the frequency with which genital malignancy is clothed in the guise of a venereal disease. The malignancy may be concurrent, may be simulated or may be a direct sequel to the chronicity of one of the venereal diseases. Then again the newer venereal diseases, especially lymphogranuloma venereum, may manifest themselves as excessive, warty excrescences; polypoid growths; elephantoid hypertrophy and hyperplasia of the vulvar tegumentary and subjacent connective tissue. The surface of such growths may be ulcerated. Granuloma inguinale and chancroid disease, particularly when a superimposed fusospirochetosis is present, may be so destructive and extensive as to simulate an ulcerative epithelioma. When one of these

venereal diseases is mistaken for malignancy it is merely an error, but when a malignant process is diagnosed as a venereal infection and treated as such, it is indeed a sad and grave mistake.

The following cases are presented to emphasize certain of the points in question:

### 1. MALIGNANCY AS A SEQUEL TO VENEREAL DISEASE

CASE I. A white male, aged 33, was referred to the author with a progressive and destructive lesion of the penis. (Fig. 1A.) For two and one-half years he had received first, extensive antiluetic treatment, then a full course of potassium and antimony tartrate. Biopsies were taken on two occasions and examined by competent pathologists who reported them negative for malignancy. We found that repeated chaneroid skin tests were positive, Frei tests and blood Wassermann and Kahn reactions negative. Stained films from the lesion revealed fusospirochetes and organisms resembling Ducey bacilli. Biopsy now disclosed multiple foci of early epitheliomatous change (epithelioma in-situ). (Fig. 1B.) Radical operative procedures were undertaken with restitution to good health for six months. Then a recurrence appeared. Biopsy revealed an advanced type of epithelioma. (Fig. 1C.)

CASE II. A colored male, aged 28, is presented to compare the appearance and deformity caused by granuloma inguinale of seven years' duration. (Fig. 2.) Recrudescences have occurred with lapses of therapy. More recently x-radiation has improved the lesions considerably.

CASE III. A colored female, aged 49, has suffered with the various syndromes of lymphogranuloma venereum for seventeen years.

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† From the Department of Obstetrics and Gynecology, Subdepartment of Experimental Medicine, University of Georgia School of Medicine. Aided in part by a grant from the U. S. Public Health Service to the University of Georgia group working on the newer venereal diseases, Dr. Richard Torpin, chairman.



Colostomy was performed eight years ago because of marked rectal stricture. (Fig. 3A.) At that time biopsy from the anorectal margin

cum and pellagra. Extensive tartar emetic therapy resulted in eradicating the granuloma inguinale. The Frei test was positive. The labia,



FIG. 1. A, epithelioma.



FIG. 2. Granuloma inguinale.



FIG. 1. B, photomicrograph (X150) epithelioma in-situ.



FIG. 1. C, photomicrograph (X150) advanced epithelioma.

revealed chronic inflammation and granulation tissue. Condylomatous growths have appeared at the anal margin. (Fig. 3B.) Blood Wassermann and Kahn reactions, Frei and chancroid tests were positive. Biopsy taken from the same site revealed an epidermoid carcinoma and chronic inflammatory changes suggestive of venereal lymphogranuloma. The rectum was excised at autopsy and is shown in Figure 3A.

CASE IV.\* A colored female aged 23, had been hospitalized on several occasions for granuloma inguinale, lymphogranuloma vener-

which recently had enlarged considerably, were covered by warty ulcerations and were excised.

The pathologic report by Dr. E. R. Pund is interesting: "Peritubular lymphocytic and plasma cell infiltration, dilation of lymphatics, fibrosis. Papillomatous hyperplasia of the epithelium. In several areas the epithelium is anaplastic and invades. Impression: Epitheliomas developing upon lymphogranuloma venereum." (Fig. 4.)

## II. MALIGNANCIES MISTAKEN FOR VENEREAL DISEASES

CASE V. A white female, aged 50, was referred to the author as a case of lymphogranu-

\* This case was previously reported by Pund, Greenblatt and Huie;<sup>1</sup> Cases I, III and IV were previously reported in greater detail by Cardwell and Pund.<sup>2</sup>

loma venereum of nineteen months' duration which would not respond to a variety of therapies. The lesion started as an indurated bubo

CASE VII. A colored female, aged 55, was referred with a genital lesion diagnosed as lymphogranuloma venereum. There were ele-

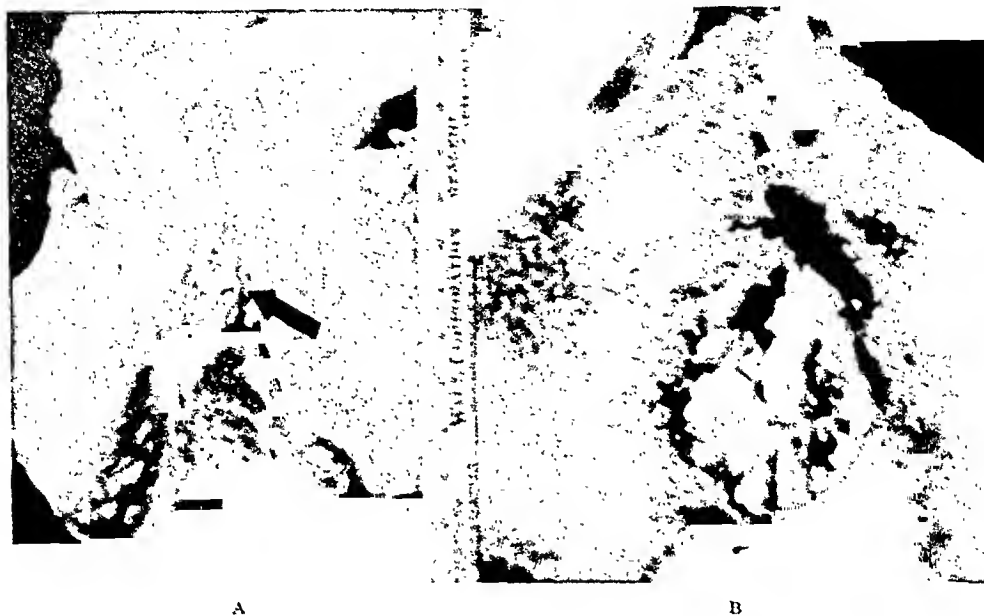


FIG. 3. A, rectal stricture of lymphogranuloma venereum. B, squamous cell carcinoma of anus.

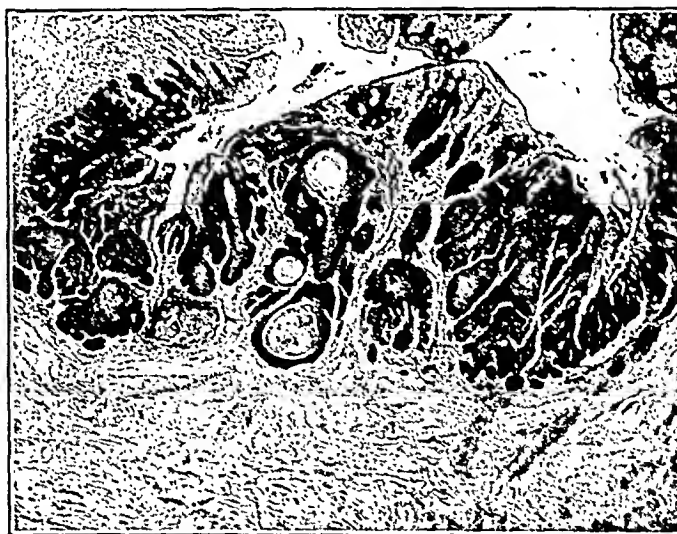


FIG. 4. Multicentric foci of epithelioma developing upon lymphogranuloma venereum. (From Pund, Greenblatt and Huie, in *Am. J. Syph., Gonorr., & Ven. Dis.*, 22: 495, 1938.)

in the left groin, which ultimately broke down. (Fig. 5.) Repeated Frei and chancroid tests as well as blood Wassermann reactions were negative. Biopsy revealed a squamous cell carcinoma.

CASE VI. A male, aged 25, may be presented as a contrast to Case V. In many respects certain similarities in their marked ulcerative and destructive features may be noted. (Fig. 6.) However, this proved to be a destructive type of chancroidal infection of nine months' duration which responded rapidly to chancroid vaccine and sulfanilamide therapy.<sup>3</sup>

phantiasis of the labia, and marked induration and ulceration of the vagina. (Fig. 7.) Frei and chancroid tests were negative. Biopsy revealed squamous cell carcinoma.

CASE VIII. A colored female of 19 years presented herself at the clinic with elephantiasis of the labia and ulceration of the vagina. (Fig. 8.) The Frei test was positive. This case of lymphogranuloma venereum is mimicked in a measure by the malignancy in Case VII.

CASE IX. A colored female, 38 years of age, with a positive blood Wassermann reaction

and an ulcerative granulomatous growth about the anus had received antisyphilitic treatment for five months. (Fig. 9.) The lesion had been

CASE XII. A white male, aged 19, was hospitalized with marked destruction of the glans penis. (Fig. 12.) Blood Wassermann and Kahn



FIG. 5. Squamous cell carcinoma.

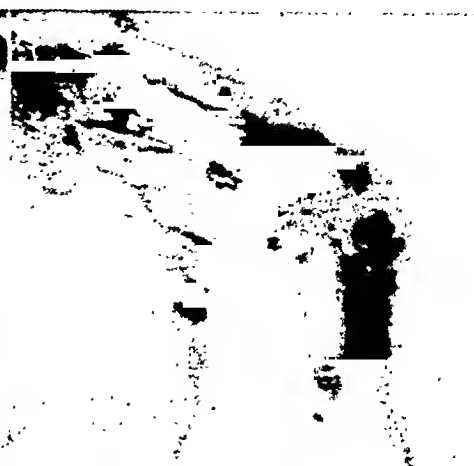


FIG. 6. Chancroid disease.



FIG. 7. Squamous cell carcinoma of vagina.



FIG. 8. Lymphogranuloma venereum with ulceration of vagina.

considered as syphilitic by her physician. Biopsy revealed a squamous cell carcinoma.

CASE X. A colored female, aged 19, with mild elephantiasis of the labia and an anal syndrome marked by ulcerated growths, presented herself at the clinic. (Fig. 10.) The Frei test was strongly positive. Note the similarities of the anal lesions in this case of acute lymphogranuloma venereum and the carcinoma in Case IX.

CASE XI. A colored male of about 35 years of age had received antiluetic treatment for eight months without benefit to an ulcerative lesion of the penis. (Fig. 11.) The chancroid test was positive, the Frei test negative and biopsy report indicated an advanced epithelioma.

reactions, chancroid and Frei tests were negative, and only fusospirochetes could be found in fresh smears to account for the lesions. These healed promptly under therapy. (This case is included through the courtesy of Dr. Z. McDaniel.) Contrast this lesion with that of Case XI.

CASE XIII. A colored male, about 40 years of age, was brought in for diagnosis by a public health physician from a neighboring state. The patient had received antiluetic treatment (because of a positive Wassermann) and when the lesion failed to respond, a course of Fuadin was given in the belief that the lesion might be granuloma inguinale. Chancroid and Frei tests

were positive. Biopsy revealed an advanced epithelioma (Fig. 13.)

CASE XIV. In a colored male a chancroidal

the clitoris. The Frei test was positive and the chancroid test negative. (Fig. 15.)

CASE XVI. A colored female, aged 30, pre-



FIG. 9. Epithelioma of anus.



FIG. 10. Lymphogranuloma venereum (genitoanal syndrome).

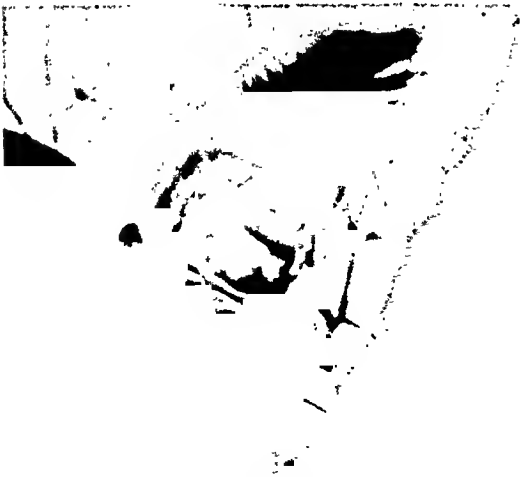


FIG. 11. Epithelioma of penis.



FIG. 12. (Primary?) fusospirochetal infection.

ulcer had sharply destroyed the whole of the glans. The clinical appearance was not unlike that of an epithelioma. (Fig. 14.)

### III. NEOPLASIA OF VENEREAL ORIGIN

CASE XV. A colored female, aged 28, presented herself at the clinic with a pendulous mass, the size of a small orange, connected to

sented herself at the clinic with massive growths involving the vulva and clitoris. A large papillomatous mass, 8 by 7 cm. in size, occupied the right lower vulvar region and perineum. The surfaces were covered by fine warty excrescences. (Fig. 16.) Ulceration was present within the vagina. Blood Wassermann and Kahn reactions, Frei and chancroid tests were all

positive. No improvement occurred under antiluetic treatment. The case finally proved to be one of lymphogranuloma venereum and granuloma inguinale.

growth extending from the lower right labium majus to the anus and another smaller one on the left labium majus. The surfaces were irregularly marked by grooved tracings and the



FIG. 13. Epithelioma.



FIG. 14. Chaneroid.



FIG. 15. Lymphogranuloma venereum.



CASE XVII. A colored female, aged 28, was referred to our clinic for diagnosis with numerous papillary growths about the pudendal region. These were of many sizes and shapes and the colors varied from crimson to a violaceous hue. (Fig. 17.) Chaneroid skin test was positive, Frei test negative. Biopsy report was condyloma acuminata.

CASE XVIII. A colored female, aged 22, presented herself with a massive firm tumor-like

color was pink to pinkish gray. (Fig. 18.) Frei, chaneroid and blood Wassermann reactions were all positive. Excision was performed and the histologic report was lymphogranuloma venereum and granuloma inguinale.

CASE XIX. Granular growths of the cervix, red and beefy in appearance, bleeding easily, are occasionally seen in our clinic. Figure 19 is a drawing of the cervix of a colored female, aged 33, who had been bleeding irregularly for three

months. A diagnosis of carcinoma of the cervix was made and radium applied. Biopsy report was granuloma inguinale. The pathognomonic

relationship between ulcerative lesions of long standing, neglected through indifference of the patient or faulty diagnosis and



FIG. 16. Lymphogranuloma venereum and granuloma inguinale.



FIG. 17. Condyloma accuminata.



FIG. 18. Granuloma inguinale and lymphogranuloma venereum.

cells were numerous throughout the sections. There was no evidence of malignancy.

#### REVIEW OF LITERATURE

Cardwell and Pund<sup>2</sup> reported five cases in which venereal disease was complicated by the development of carcinoma on the involved sites. They suspected an etiologic

maltreatment on the part of the physician. Liccione<sup>4</sup> noted the development of malignancy in two cases of inflammatory rectal stricture which were under direct observation. In spite of an extensive search of the literature he was unable to find this sequence of lymphogranuloma venereum and adenocarcinoma. David and Loring<sup>5</sup>

recently reported squamous cell carcinoma of the rectum in two proved cases of lymphogranuloma venereum with anorec-

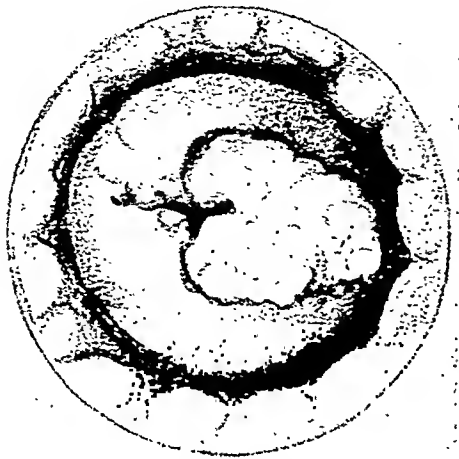


FIG. 19. Granuloma inguinale of the cervix.

tal syndrome of long standing. Rosser, as well as Singleton, in the discussion of David and Loring's paper, refused to accept this sequence but preferred to lay blame on the fistulae which arose secondary to lymphogranuloma venereum as the cause of carcinoma. Lisa<sup>6</sup> reported one case of rectal lymphogranuloma venereum with a perineal fistula of ten years' duration in which a squamous cell carcinoma developed at the anus. Pund, Greenblatt and Huie,<sup>1</sup> in an evaluation of the rôle of the biopsy in the venereal diseases, found that epithelioma was superimposed upon one of the venereal diseases in four of the seventy-five biopsies studied. This led them to suspect a causal relationship. Reaves<sup>7</sup> drew attention to one case of granuloma inguinale and another where lymphogranuloma venereum of long standing was later accompanied by malignancy. Reaves suggested that chronic irritation over a long period of time is conducive to malignancy and that a "lookout for such pathology" is advisable.

#### DISCUSSION

The relation between persistent irritating chronic inflammatory processes and malignancy has long been known. It appears that certain individuals possess an epithelial integument that responds easily

to irritant stimuli so that carcinoma may readily follow. This is apparent from a scrutiny of Cases I and III where the earliest neoplastic changes may be characterized as "epithelioma-in-situ." The persistent irritant in these cases was wrought by the chancroidal infection, with superimposed fusospirochetosis in one and the virus of lymphogranuloma venereum in the other. Biopsies in years past revealed nothing more than chronic inflammatory tissue. A biopsy retaken at the site some years later supplied evidence that malignant transformation had taken place.

Between granuloma inguinale and malignancy, the relationship is not so clear as in lymphogranuloma venereum. Few references are to be found in the literature. One case was reported by Cardwell and Pund<sup>2</sup> of granuloma inguinale of the cervix in which a malignancy was superimposed. Another case was reported by Reaves, as mentioned previously. On the other hand granuloma inguinale is frequently mistaken for malignancy clinically and not infrequently histologically. Briggs<sup>8</sup> mentioned that this disease is most commonly confused with that of lues but many cases treated for carcinoma have doubtless been venereal granuloma. Pund and Greenblatt<sup>9</sup> reported on two cases of granuloma inguinale of the cervix which were at first clinically mistaken for epithelioma. In fact in one of these cases the suspicion was so great that radium was applied at the time of biopsy. Histologic errors are made, as is implied in the report by Cannon<sup>10</sup> who twice presented cases which ultimately proved to be granuloma inguinale but were diagnosed as epithelioma by biopsy.

Randall, Small and Belk,<sup>11</sup> Gage,<sup>12</sup> and Pund and Greenblatt<sup>13</sup> in their studies on the histology of granuloma inguinale have warned against such an error. The following statement by the latter authors is perhaps representative, "The rete pegs become elongated and the resultant relationship so distorted that islands of keratinized epidermis are frequently found deep in the section. These give the appearance of epithelial pearl formation and may simulate



an early epithelioma." The ulcerative bubo as describe in Case v is perhaps unusual. Behcet<sup>14</sup> recently reported on a carcinoma of an inguinal gland which resembled lymphogranuloma venereum. In 1933 Favre<sup>15</sup> wrote on cancerous buboes, inflammatory in appearance which are simulated by lymphogranuloma venereum.

The presence of fusospirochetes in genital lesions<sup>16</sup> may result in marked destruction of tissue so that the lesion may simulate ulcerative and destructive types of epithelioma. Hyperplasia or neoplasia of venereal origin frequently presents problems in differential diagnosis. Cases x, xvi, xvii, xviii, and xix of our series are such examples. These at times may be excusably mistaken for malignant neoplasia.

A biopsy in such conditions is almost essential. Positive blood Wassermann reactions or Frei tests in themselves may prove a snare and a delusion by masking the true diagnosis of a malignant process. The rôle of the biopsy cannot be overemphasized, not only to rule out malignancy but as an aid in diagnosis. Proper histologic study may reveal treponema pallida, or the pathognomonic cell of granuloma inguinale or suggest the diagnosis of chancroid disease or lymphogranuloma venereum. It must be evident as an analysis of the cases reported show, that a positive Wassermann or a positive chancroid<sup>17</sup> or Frei test does not necessarily label the lesion in question and that biopsy can prove quite a resourceful undertaking.

#### SUMMARY

1. Too often benignant neoplasia of venereal origin has taken precedence, in the thoughts of the physician, over malignant neoplastic disease with dire consequences to the patient.

2. It must be stressed that an unusual genital lesion should cause the physician to be mindful that malignancy may exist either as a primary process, as a sequel to one of the venereal diseases, or concomitantly with one of them.

3. The importance of the biopsy and its interpretation in the differentiation of the

venereal diseases by pathologists trained in this work cannot be overestimated. The biopsy must be placed side by side with such procedures as the blood Wassermann and Kahn reactions, the Frei and chancroid skin tests, if progress in diagnosis is to keep abreast with the great program for the public good by the sentinels of the public health.

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# THE MANAGEMENT OF THE BREECH POSITION\*

SAMUEL S. ROSENFELD, M.D.

Attending Obstetrician, Jewish Memorial Hospital

NEW YORK CITY

MANY excellent papers have been written on the statistics and management of the breech position. The reason for the writing of yet another paper is merely to emphasize a few important points which would materially diminish the number of babies lost.

One hundred and three consecutive cases of breech extraction were performed. Three cases of twins are excluded because the weight of the individual children was less than  $5\frac{1}{2}$  pounds.

TABLE I  
PARITY

Para 0.....	76
Para 1.....	16
Para 2.....	4
Para 3.....	2
Parity undetermined.....	5

There was no maternal mortality. The gross fetal mortality was eight, or 7.76 per cent. The corrected fetal mortality revealed four fetal deaths, or 3.8 per cent. Forceps were applied to the aftercoming head thirteen times. Peculiarly enough, the largest child extracted in this series ( $10\frac{1}{2}$  pounds) did not require forceps on the aftercoming head; some of the other large infants were likewise born without such aid.

*Complications.* One child developed an Erbs palsy. This was a case in which the cord was prolapsed. The cervix was dilatable and a manual dilatation and rapid extraction had to be performed to save the baby.

One mother suffered a third degree tear which was immediately repaired and which was completely healed before she left the hospital.

*Discussion of Fetal Mortality.* CASE I. Delivery was very easy. The baby appeared

weak and limp. Congenital lues was strongly suspected in this case.

CASE II. The cord was prolapsed and neither the family doctor nor I could hear the fetal heart prior to the commencement of the delivery.

CASE III. The mother had a premature separation of the placenta and the fetal heart could not be heard for some time prior to the delivery. She delivered spontaneously.

CASE IV. The mother had a contracted pelvis. When I first saw her she had been in labor for a long time and had had many vaginal examinations. There seemed to be a mild disproportion. I deemed it best under the circumstances to deliver naturally. Fetal death was most probably due to cerebral hemorrhage. I have since delivered this patient by cesarean section of two living children and each time the presentation was breech.

CASE V. Fetal heart could not be heard prior to delivery.

CASE VI. Macerated fetus.

CASE VII. Baby died about a week before onset of labor.

CASE VIII. Baby died about a week before onset of labor.

From even a brief perusal of this mortality table one can easily see that the results in this series could have been better if all the cases had been supervised throughout pregnancy and labor by an experienced obstetrician.

## DISCUSSION

Our statistics can be improved if we bear in mind a few important facts and points.

In the first place it is as important, perhaps even more important, to know when not to attempt a breech extraction as it is to know when to perform one. This problem can best be solved after a good deal of training and adequate personal experience.

\* From the Department of Obstetrics, Jewish Memorial Hospital.

Its solution requires fine obstetrical judgment. In my opinion a woman in labor whose infant presents by the breech is entitled to the services of an experienced obstetrician. Breech extraction should not be attempted in cases where there is evidence of marked disproportion. This is especially true in the case of the nullipara. In these instances both the mothers and babies are better served by cesarean section. This does not mean that cesarean section is the method of choice in treating breech positions; indeed, I have performed cesarean section only three times for the delivery of the breech and I have delivered vaginally some infants weighing over 9 pounds in nulliparous women.

It cannot be too strongly emphasized that no attempts at delivery should be attempted until the cervix is fully dilated. This rule should not be violated except in cases where the child is in jeopardy and even then nothing should be attempted unless the cervix is soft and fully dilatable. It is far safer to permit the fetus to perish than to attempt breech extraction through an undilated cervix. Violation of this fundamental rule ends in tragedy to either the mother or the child and oftentimes to both.

However, I believe that a goodly number of babies are lost by procrastination and a do-nothing policy after full dilatation of the cervix has been attained. This is especially true in cases of frank breech presentation. The danger of fetal asphyxiation due to interference with the circulation through the umbilical vessels is very great at this particular stage of a breech labor. My policy after the stage of full cervical dilatation has been reached is not to interfere until the buttocks present at the vulva, provided there is no impairment of the fetal heart tones.

In the face of either failure of advancement or abnormal changes in the fetal heart sounds the breech is broken up and an extraction performed. It is preferable to bring down both legs but when this proves impossible the anterior leg is pulled down and its mate also as soon as it can be

grasped. My technique in bringing down the leg is to go directly to the foot, grasp the child's ankle and pull it downwards and forwards. The infant's knee flexes during this motion. From here on Potter's technique is followed closely. Haste is avoided. When the umbilical cord comes into view it is pulled out a few inches on the vulva so as to avoid stretching the umbilical vessels and to minimize pressure.

In the occasional case where both shoulders cannot be delivered anteriorly, i.e., under the symphysis, I am satisfied to deliver one posteriorly.

In my opinion one of the greatest factors tending to decrease the fetal mortality in breech cases is the popularization of the "aftercoming head" forceps, for which we owe a great debt of gratitude to the late E. W. Piper. In the better obstetrical clinics one now sees less and less of the pull, agonizing to both the baby and the operator.

If a slowly performed Smellie-Veit maneuver with moderate pressure on the head by an assistant from above, does not effect prompt delivery the Piper aftercoming head forceps are immediately applied. In a few instances these forceps have slipped and I have used standard Elliott forceps and effected delivery without any trouble. I have never yet failed with the Elliott forceps.

#### SUMMARY AND CONCLUSIONS

One hundred three patients were delivered by breech extraction with no maternal mortality.

The gross fetal mortality was 7.76 per cent and the corrected mortality 3.8 per cent. Had these patients been under the supervision of competently trained obstetricians the corrected fetal mortality in this series might well have been in the neighborhood of 1 per cent.

Cases where appreciable disproportion exists between the passages and the passenger had best be treated by cesarean section.

Anesthesia is essential in practically all cases. I have found it rather hazardous to rely on the patient's coöperation during the course of a breech delivery. At the crucial moment she is likely to become frightened, hysterical and unreasoning and the infant can very easily be lost at this late stage. I have therefore made it a rule to anesthetize all my breech cases and thus eliminate a doubtful source of coöperation.

No attempts at delivery should be attempted until the cervix is fully dilated.

After full dilatation of the cervix delay in progress or change for the worse in the fetal heart or rhythm should call for prompt intervention.

The legs can conveniently be brought down by grasping the ankles, making traction downwards and forwards and thus flexing the knees.

At the least sign of difficulty in the delivery of the aftercoming head, forceps should be immediately applied.



BREECH positions carry a slightly greater risk to the infant, but in nine cases out of ten, the outcome is entirely satisfactory. From—"Expectant Motherhood" by Eastman (Little, Brown and Company).

# RUPTURE OF THE PREGNANT UTERUS\*

HENRY S. ACKEN, JR., M.D.

Assistant in Obstetrics and Gynecology, Methodist and Kings County Hospitals

BROOKLYN, NEW YORK

**R**UPTURE of the pregnant uterus is an infrequent complication of the gravid state, but the maternal and fetal mortality associated with it is so high that serious consideration may well be given to it.

In 25,935 deliveries at the Methodist Episcopal Hospital in Brooklyn between May 1, 1924 and January 1, 1939 there were fifteen cases of rupture of the pregnant uterus. The difficulty in diagnosis in such cases is indicated by the fact that three were recognized only at autopsy and it may be that others occurred without our knowledge. Seven maternal deaths and seven stillbirths occurred among the fifteen cases.

Rupture of the uterus may occur either in a uterus which has never previously suffered laceration of its musculature, or in a uterus which has been previously incised. The cases presented here were accordingly divided into primary and secondary groups. There were seven cases in the primary group and eight in the secondary. All of the secondary cases followed cesarean section. Because of the differences in etiology, diagnosis and treatment these groups will be considered separately.

In the primary ruptures six showed a laceration completely through the uterine wall, one exhibited two lacerations of the wall—neither of which extended completely through the musculature. In four cases trauma of delivery or attempted delivery was the etiologic factor in the rupture; in one case there was some question as to the part played by delivery; in one case no history or evidence of trauma could be ascertained; while in the seventh case rupture occurred apparently near the end

of a short but very severe labor, in a patient who had had a previous amputation of the cervix. This last mentioned case was the one with the incomplete lacerations and was the only one in whom external hemorrhage was a factor.

TABLE I	
RUPTURE OF PREGNANT UTERUS	
Total deliveries May 1, 1924, to	
January 1, 1939.....	25,935
Number of ruptured uteri.....	15
Maternal deaths.....	7
Fetal deaths.....	7

One of these cases occurred on the private service and six on the ward service. Four of the latter group were brought to the hospital by ambulance and had had little or no prenatal care. The one private patient was delivered by very easy breech extraction. She died within an hour of delivery and autopsy revealed a rupture along the border of a fibroid tumor. Review of this case history indicates that rupture occurred before delivery.

Two of the six ward patients had been faithful visitors to the clinic. One of these was the patient with the incomplete rupture. Evidence of hemorrhage was noted after full dilatation was reached, and mid-forceps were applied for delivery. This patient had had a previous amputation of the cervix and had a rather short labor characterized by extremely strong uterine contractions. In view of the evidence of hemorrhage before delivery, blame for the rupture was not placed on the forceps application. This patient bled to death and autopsy showed two incomplete lacerations high in the lower uterine segment. The other clinic case was a placenta previa treated by bag induction and delivered by

\* From the Department of Obstetrics and Gynecology of the Methodist Hospital, Brooklyn, New York. Read before the section on Obstetrics and Gynecology, New York Academy of Medicine, January 24, 1939.

version—the baby weighed only 1,148 Gm. (2 pounds 8½ ounces)—and the rupture probably occurred in manual removal of the placenta. Prompt hysterectomy preceded and followed by massive transfusions gave a good maternal result.

TABLE II  
TYPES OF RUPTURE

Primary ruptures.....	7
Maternal deaths.....	5
Fetal deaths.....	5
Secondary ruptures.....	8
Maternal deaths.....	2
Fetal deaths.....	2

The four ambulance cases were neglected patients who had been in labor for from twenty to forty hours with membranes ruptured for periods of seventeen to forty-nine hours. One had a transverse presentation with moderate vaginal bleeding. Bag induction was done, followed by version and extraction. The extraction was accomplished before complete dilatation and despite the size of the baby—1,956 Gm. (4 pound 5 ounces)—a laceration of cervix and uterus occurred that caused death. One patient was admitted in moderate shock. No history was obtainable because of language difficulty. The patient was treated for shock and at full dilatation was delivered of a breech presentation by embryotomy. She sustained a cervical laceration that extended into the lower uterine segment, and died. Another patient was admitted in moderate shock after instrumentation at home. She was treated for shock and delivered at full dilatation by forceps and craniotomy. Death occurred one hour after delivery and a complete laceration 6 cm. in length was found beneath the bladder. The seventh patient was fully dilated on admission with the face presenting. She was delivered without difficulty by mid-forceps after conversion of the face presentation. An attempt had been made to deliver the face as such and rupture of the uterus was noted after this attempt. Prompt hysterectomy, preceded and followed by transfusion gave a good maternal result.

Certain factors were sufficiently common to most cases in this group to attract atten-

tion. All the patients were multiparae, having had from one to nine previous pregnancies. All were in or past their middle thirties and three were 43, 44, and 45 years old, respectively. Five of the patients were definitely obese, each weighing 200 pounds or more. Contraction of the maternal pelvis was not a factor, all but one patient having normal measurements. Nor could excessive fetal size be considered a uniform cause, since there were but two oversize babies in the series—one of 10 pounds 4½ ounces and one of 10 pounds 12½ ounces. The other fetal weights ranged from 2 pounds 8½ ounces to 8 pounds 14 ounces. Abnormal presentations, however, were frequent, there being two breech presentations, one transverse and one face presentation. Placenta previa was present in two instances and bag induction was the elected method of procedure in each. In neither instance was the bag responsible for the rupture. Manual removal of the placenta and delivery through an incompletely dilated cervix were the traumatic factors in these two cases.

Shock was the most prominent symptom of primary rupture. This was not always immediate and severe, but became much more pronounced after delivery. When the rupture had occurred prior to admission to the hospital the patient was moderately shocked on admission but responded to appropriate therapy, only to suffer greater shock and death following delivery. External hemorrhage was a factor in only one case—that of the incomplete laceration. In the remainder there was no unusual vaginal bleeding. When death occurred it took place within two hours of delivery in all but one instance, one patient surviving for almost twenty-four hours. The two patients who survived were treated by immediate hysterectomy, preceded and followed by transfusions of 500 c.c. or more. One patient received 1500 c.c. of blood within ninety minutes and 500 c.c. more within the next forty-five minutes.

The most important factor in these cases is early diagnosis. This diagnosis in many

instances can be made only by inserting the examining hand inside the uterus. This procedure is warranted in any patient who comes into the hospital with a history of unsuccessful attempts at delivery at home or who is subjected to a potentially traumatic delivery in the hospital. The presence or absence of fetal heart tones is not of any consistent significance, for rupture of the uterus can occur without loss of fetal life. Abdominal palpation alone frequently gives insufficient or no evidence. In only one instance was there rupture of the anterior wall of the uterus and this rupture lay beneath the bladder. The location of the rupture and the obesity so frequently encountered caused considerable variation in the amount of abdominal tenderness elicited. A fairly consistent symptom was the cessation of labor pains after their onset, followed by steady abdominal pain. Even this was not uniformly present.

Prevention of rupture is the most important consideration and such prevention is possible. Every case of primary rupture of the uterus is a failure on the part of the physician because trauma plays so great a rôle. Delivery of the fetus—regardless of its size—before full dilatation is contraindicated. The multipara, particularly if elderly or obese, should be regarded as a potential subject for rupture of the uterus and should be managed with all the care and skill accorded to the primipara. The factors of obesity and more advanced age apparently render tissues more susceptible to the effects of traumatic delivery. It is interesting to note that while trauma was not considered a definite factor in two of our cases, there were no cases in the series where the patient had a perfectly spontaneous delivery.

Secondary rupture of the pregnant uterus presents a somewhat different situation with which to cope. Six of these patients were on the private service and two on the ward. All eight of these secondary cases followed cesarean section. They occurred in 304 repeat cesarean sections performed during this fourteen year period. In all but

one instance the previous operation had been a classical one, the single exception being a previous low flap operation not performed at our hospital. The maternal and fetal mortality in the secondary group was lower than in the primary—there being only two maternal and two fetal deaths in this group. Three patients had had one previous cesarean, five had had two such operations. In all three cases where rupture followed a single previous operation, the ruptures were found in the course of routine secondary operations. No signs or symptoms of rupture were noted by the patient. These patients did well. Two were treated by suture of the rupture, and one by hysterectomy.

Of the five cases where rupture was preceded by two cesarean sections, two patients died. All five patients exhibited signs and symptoms of the rupture—sudden abdominal pain, sometimes followed by a few weak labor pains, abdominal tenderness, rigidity, increasing pulse rate and falling blood pressure. The abdominal signs were more prominent in the secondary group, undoubtedly because the rupture occurred in the anterior uterine wall. In none of these patients were the membranes ruptured nor did any of them exhibit external bleeding.

Because of the history of previous cesarean sections the diagnosis was made comparatively easily and promptly. In all but two cases operation was performed immediately after the diagnosis was made. In these two cases an unaccountable delay of three to four hours occurred. Both these patients died postoperatively and the cause of death in each instance was ascribed to pulmonary embolus. Neither diagnosis was confirmed by autopsy, but careful review of the charts tends to support the designated cause of mortality, since death was sudden and associated with unusual increases in respiratory and cardiac rates.

In one of the secondary cases the rupture occurred at seven months; in this instance the products of conception were found entirely in the abdominal cavity. This patient

was treated by suture of the ruptured scar, thus preserving the uterus, and made an uneventful recovery. No sterilization was done because of her condition but there is no record of her having become pregnant again. In the remaining seven cases, rupture occurred during the last month and in none of these was there extrusion of the uterine contents. The rupture was treated solely by suture of the wound after freshening of the edges. Sterilization was done in only two instances because of the difficulty of performing this operation in the face of adhesions and the unsatisfactory condition of the patients. Hysterectomy was done in one case, a patient who had exhibited no symptoms of rupture.

Secondary rupture of the uterus is largely a question of prevention. It occurs sufficiently frequently—eight in 304 cases—to require consideration in any patient who has been subjected to cesarean section, particularly classical cesarean section. Patients should be carefully instructed to report to the physician any unusual abdominal pain or discomfort occurring in the last trimester of pregnancy. And during this period the attention of the physician should be directed toward an evaluation of the previous scar. Any evidence of overdistention, weakness, or incipient rupture should indicate prompt operative interference.

The treatment of secondary rupture once it has occurred should, wherever possible, consist of suture of the ruptured scar. Unlike the primary ruptures, these cases require no preliminary intra-uterine exploration; nor have they usually been exposed to the dangers of prolonged labors and periods of ruptured membranes. Hence the simpler procedure of suturing the laceration is more frequently feasible. Sterilization should also be done if conditions are favorable and time permits.

Follow-up has been possible on six of the eight survivors in this series of fifteen patients. Three of those followed were potentially fertile and one became pregnant. Her pregnancy occurred within twelve months of the rupture of her uterus. Therapeutic abortion was done in the interest of this patient who had two living children and who had so recently undergone such a serious complication of pregnancy. Her convalescence was uneventful and she did not again become pregnant. The other patients followed have remained in good health and no further operative interference has been necessary in any instance.

#### CONCLUSIONS

1. Rupture of the pregnant uterus is an infrequent occurrence with an extremely high maternal and fetal mortality.
2. Primary rupture of the pregnant uterus is usually caused by trauma of delivery or its attempt.
3. Prevention of primary rupture depends upon constant care during labor and delivery.
4. The obese elderly multipara is particularly subject to primary rupture of the uterus.
5. Shock is the most prominent symptom of primary rupture of the uterus.
6. The treatment of primary rupture of the uterus is transfusion, hysterectomy, transfusion.
7. In our series secondary rupture of the uterus was invariably preceded by cesarean section, particularly classical cesarean section.
8. Prevention of secondary rupture of the uterus depends on the constant vigilance of the physician and the full coöperation of the patient.
9. The treatment of secondary rupture of the uterus can usually be more conservative than that of primary rupture.



# CARCINOMA OF THE BREAST\*

F. G. HIDDE, M.D.,

J. P. MALEC, M.D.

AND

JOSEPH W. GALE, M.D.

MADISON, WISCONSIN

CANCER leads to nearly 10 per cent of all deaths. It ranks second in cause of death, being surpassed only by cardiovascular disease in frequency. In cancer mortality statistics mammary malignancies rank third. In the female one-third of malignant diseases arise in the breast. Such, in brief, is the incidence and mortality of carcinoma of the breast. Barring any radical discoveries in prevention or treatment, statisticians estimate that mammary cancer incidence and mortality will continue to increase during the next thirty-five to fifty years to reach a maximum at approximately one and one-half the present rate. This increase is brought about by the greater percentage of people living into the cancer age as the result of preventive medicine, as well as a decline in the birth rate which accordingly raises the proportion of older people in the population.

It is the purpose of this paper to evaluate the results of mammary cancer treatment at the Wisconsin General Hospital from 1924 to 1936.

Like most other observers during the past quarter century we have noted no new symptoms of mammary cancer. In diagnosis we have learned that the classical signs associated with breast carcinoma in contradistinction to benign breast lesions are generally the advanced signs of this disease. Today with a better education of the laity concerning the significance of any breast tumor or symptom, an increasing number of borderline cases is brought to the physician in which a clinical diagnosis is difficult if not impossible. Therefore, we concur with the aphorism that every tumor of the

breast is a cancer unless microscopic study proves it to be otherwise.

In treatment we have no new procedure but can only emphasize that the principles of "cancer cure" demand the removal or destruction of all neoplastic tissue. We believe that any mastectomy which fulfills the principles of Halstead and Willy Meyer, i.e., first, the removal of all actual and probably involved tissue within the limits of surgical access; and second, the perfection of an operative technique which interrupts efferent lymphatic channels from the breast early in the course of the operation, will, along with carefully selected irradiation therapy, produce the greater percentage of ultimate "cancer cures."

During the period of eleven years there were admitted to the hospital 318 patients for treatment of mammary carcinoma. These cases have been divided into three groups.

*Group I.* Patients who received primary treatment at this hospital for mammary carcinoma.

*Group II.* Patients who received only irradiation or no treatment at this hospital.

*Group III.* Patients who had received primary treatment elsewhere and were admitted here for further treatment.

In this analysis we have chosen a clinical classification similar to that of Pfahler,<sup>1</sup> but one which is somewhat more complex. This is not based in any sense on the microscopic grading used by Broders.

Stage 1 includes a small group of very early carcinomas 2 cm. or less in size with no metastases.

\* From the Surgical Service, University of Wisconsin, State of Wisconsin General Hospital.



Stage II designates masses larger than those of stage I but showing again no metastases. This group is further subdivided into IIA to designate that relatively rare clinical picture of an ulcerating tumor without metastases.

Stage III represents by far most frequently seen type at the surgical clinic, i.e., one with a definite carcinoma with axillary metastases. Stage IIIA includes those patients with axillary metastases and ulceration over the main tumor mass. We do not consider the latter usually as an inoperable group either with or without preoperative irradiation.

Stage IV includes the remainder of all cases permanently inoperable or upon whom a simple mastectomy is performed to rid the patient of a sloughing mass. Stage IV represents those patients with disseminated metastases (supraclavicular, en cuirasse, pulmonary, or osseous). It is further subdivided into Stage IVA which presents distant metastases plus ulceration.

TABLE I  
AGE INCIDENCE OF CARCINOMA IN 177 CASES

Age Group	No. of Cases	Per Cent
20-24.....	0	0
25-29.....	2	1.2
30-34.....	6	3.2
35-39.....	16	9.1
40-44.....	31	17.2
45-49.....	21	11.8
50-54.....	20	11.3
55-59.....	27	15.3
60-64.....	21	11.8
65-69.....	21	11.8
70 and over.....	11	6.1
Unknown.....	1	1.2
	177	100.0

Group I includes 177 cases of carcinoma in which patients came for primary treatment and finally went on to an operative procedure, either radical or simple mastectomy. Seventy (39.5 per cent) of the patients were premenopausal and ninety-six (54.3 per cent) were in their postclimacteric period; the menopausal status of eleven (6.2 per cent) was unknown. The

tumor was primarily on the left side in ninety-four cases (53.3 per cent), on the right side in seventy-five (42.3 per cent), and bilateral in eight (4.4 per cent).

The age incidence (Table I) shows a quite steady occurrence in the age groups from 40 to 70 years. Separate, slightly higher peaks may be noted in the years 40 to 44, and 55 to 59.

Mastectomies, as previously stated, were either simple or radical. The radical type of operation, fashioned on the principles set forth in the Willy Meyer and Halstead techniques, was accomplished in 163 cases (92.2 per cent). Simple mastectomy was thought to be indicated in only fourteen cases (7.8 per cent). We feel that the indications for the latter procedure are few but definite: (1) severe cardiac disease and distinct inability to withstand a long procedure (two cases); (2) patients in stages I or II necessarily having small tumors, unwilling to withstand a radical procedure but willing to proceed with a full course of x-ray therapy (two cases); (3) patients over 70 years of age whose general status prohibits severe operative intervention (eight cases); (4) the presence of an ulcerating mass along with systemic metastases—in such an individual it is felt that any amputation only lessens the cares of the remaining only too short life of the patient (two cases).

In all cases, before operative procedure was undertaken, there was at least a minimum of roentgenologic investigation which usually included a flat film of the chest, anteroposterior and lateral films of the spine, and a flat anteroposterior view of the pelvis. The x-ray, clinical and operative findings classified the cases into their various stages. (Table II.) A paucity of stage I and IIA patients is very obvious; the former because of the rarity of such early discovery and the latter because it is rare even in a much larger series. The relationship between stages III and II is 3 to 1 and is distinctly too great to hope for monumental strides in the treatment of breast cancer.

TABLE II  
CLASSIFICATION INTO STAGES

Stage	No. of Cases	Per Cent
I	1	0.567
II	39	22.1
IIa	1	0.567
III	116	65.5
IIIa	14	7.6
IV	5	2.9
IVa	1	0.567
	177	100.000

Postoperative mortality in the series was 3.9 per cent (seven cases). There were three chief causes of the failure of the procedure: (1) cardiac failure—three cases; (2) bronchopneumonia—two cases; (3) pulmonary embolism—two cases.

Eleven more patients (6.2 per cent) died of causes other than the carcinoma. Their span of life varied from two months to twelve years after their primary surgery. The causes of death and duration of life are indicated in Table III. This group has

TABLE III

Clinical Stage	Cause of Death	Period Post-operative
II	Pulmonary tuberculosis	3 years
II	Cardiac disease	6 years
II	Erysipelas	2½ years
II	Bronchopneumonia	12 years
III	Cerebral accident	4½ years
III	Carcinoma of the uterus	6 years
III	Cerebral accident	8 months
III	Pulmonary tuberculosis	1½ years
IIIa	Chronic nephritis	1 year
IIIa	Cardiovascular accident	2 months
IIIa	Bronchopneumonia	2 months

not been included in any of our final averages and we do not feel it should be. Most of these did not come to post-mortem examination here and the given causes of death in some may be questioned. In any event, only three lived beyond the five-year period and a single patient longer than ten years.

Exclusive of untraced patients (nineteen), postoperative deaths (seven), and

deaths due to causes other than carcinoma of the breast (eleven), there were seventy-nine patients traced and known to be dead of carcinoma of the breast as of July 1, 1938. To this number, in all probability, might well be added the general rule of those untraced. The average duration of life varied directly with the stage of the disease at the time of surgery. (Table IV.)

TABLE IV  
AVERAGE DURATION OF LIFE IN PATIENTS KNOWN TO BE DEAD OF CARCINOMA OF THE BREAST

Stage	No. of Cases	Average Duration of Life, Years
I	0	0
II	8	3.56
IIa	0	0
III	61	2.43
IIIa	7	.85
IV	2	.37
IVa	1	1.00

Besides the dead and untraced, there were seven (3.9 per cent) cases which had questionable or known metastases or other carcinoma when last seen here just prior to July 1, 1938:

Stage II. Two patients with questionable metastases.  
Stage III. Two patients with questionable metastases.  
Stage III. Two patients with known metastases.  
Stage III. One patient with carcinoma of the uterus.

This leaves, as of July 1, 1938, fifty-four patients (30.4 per cent) still living and well with no evidence of metastatic lesions. Other workers have found a similar percentage of cures.<sup>2,3,4</sup> The postoperative period ranges from three to fourteen years and all patients are in stages I to IIIa. They are grouped in Tables v and vi.

TABLE V

Stage	No. of Cases	Per Cent
I	1	1.8
II	30	55.5
IIa	1	1.8
III	18	33.3
IIIa	4	7.6
	54	100.0

TABLE VI  
GROUPED IN HALF YEAR PERIODS

Years Postoperative	No. of Cases	Percentage Living
3-3½	14	25.9
3½-4	2	3.7
4-4½	7	12.9
4½-5	4	7.6
5-5½	6	11.2
5½-6	0	
6-6½	2	3.7
6½-7	2	3.7
7-7½	1	1.8
7½-8	0	
8-8½	3	5.7
8½-9	1	1.8
9-9½	2	3.8
9½-10	1	1.8
Over 10	9	16.8
	54	100.0

Only four patients in stage II died as the result of their carcinoma, while in stage III all but eighteen were dead following their primary lesion at the time of the writing of this paper. This leaves a gross mortality rate of 13.9 per cent in stage II and 84.6 per cent in stage III.

**Group II.** This group of fifty-two patients received irradiation or no therapy at all. In twenty-eight (54 per cent) the neoplasm was primary in the right breast, in nineteen (36 per cent) in the left, and in five (10 per cent) it was bilateral on admission. Eleven of this group had a normal menstrual history while forty had passed their menopause. In one the menstrual status was not known. The age distribution is given in Table VII.

TABLE VII  
Age

Age	Number
40 to 44	6
45 to 49	5
50 to 54	5
55 to 59	6
60 to 64	10
65 to 69	8
70 or over	10
Unknown	2
	52

Fifteen (29 per cent) of the group received no treatment. Twelve of these pa-

tients are dead; the course in three is unknown. All except two of these were in stage IV in whom irradiation therapy for curative purposes was not indicated and for palliative purposes not necessary. The remaining thirty-seven (71 per cent) were given irradiation therapy for palliative purposes: (1) to heal ulcerating lesions; (2) to give relief of pain; (3) to check the growth of the neoplasm and possibly to prolong life. The duration of life is indicated in Table VIII. Eleven could not be traced. Of

TABLE VIII  
DURATION OF LIFE FOLLOWING IRRADIATION THERAPY

Duration	Group III	Group IV
6 months	1	10
1 year	1	7
1½ years	1	
2 years	2	
3 years	3	
4 years	..	1

the remaining twenty-six all have died except one—now alive two years after the beginning of x-ray therapy.

**Group III.** Eighty-nine patients were seen at this hospital after having received previous treatment elsewhere. Their ages are shown in Table IX. In forty-five (50 per

TABLE IX  
AGE DISTRIBUTION  
Age

Age	Number
30 to 34	6
35 to 39	8
40 to 44	9
45 to 49	18
50 to 54	14
55 to 59	11
60 to 64	9
65 to 69	9
70 and over	5
	89

cent) the malignancy was primarily in the right breast, in thirty-seven (41 per cent) in the left, in three (4 per cent) bilateral, and in four (5 per cent) unknown. Thirty-one had normal menses, forty-eight had passed their menopause and in ten the menstrual status was not known. Eighty-two (92 per cent) of these had had a mastectomy else-

where, with or without x-ray therapy. Two had received x-ray therapy only. Four had had a local excision and in one the type of previous treatment was not known. Recurrences and metastases occurred at various sites. (Table x.)

TABLE X  
SITE OF METASTASES

Site	Per Cent
In operative scar.....	53-59
Ulceration.....	9
Corresponding axilla.....	15-16
Corresponding supraclavicular nodes.....	11-12
Other breast.....	7-7
Systemic.....	48-54
Mainly in pulmonary tissue.....	11
Mainly in bones.....	14
Unknown.....	3

Treatment undertaken at this hospital consisted of irradiation therapy for fifty-one (57.3 per cent) of this group, radical mastectomy with irradiation therapy for seven (7.8 per cent), local excision followed by irradiation therapy for two (2.4 per cent), and no treatment for twenty-nine (32.5 per cent).

Of this group four patients are at present alive but with evidence of systemic metastases and three additional patients are alive without evidence of metastasis. One of these, a 57 year old white female, seen here in January, 1935, had a radical left mastectomy done elsewhere in November, 1934. At time of admission there was one small nodule over the sternum and fixed to it. She was given four series of x-ray treatments, the last one in March, 1936, and has remained well since, with almost complete disappearance of the presternal nodule. The second, a 63 year old white female, had a simple right mastectomy done elsewhere in June, 1932. On her admission in November, 1933, a mass was present in the right axilla and a radical mastectomy was done followed by irradiation therapy (five series). The patient at present is free of metastases. The third, a 67 year old white female, had an ulcerated mass in the right axilla following partial excision of a tumor two years previously. A biopsy in November, 1934 proved the tumor to be an adenocarcinoma

of the lingula of the right breast. Six series of x-ray treatments were given and the patient is at present without demonstrable metastases. However, an indefinite indurated mass does remain in the right axilla which on biopsy shows a chronic inflammatory reaction.

Twelve of the patients could not be traced and three died of causes unassociated with their malignancy. All the remaining patients (sixty-eight) are known to have died primarily as the result of the mammary neoplasm. Their duration of life with type of treatment is given in Table xi.

TABLE XI  
DURATION OF LIFE AFTER TREATMENT

Life Span	None	Treatment X-ray	Mastectomy	Local Excision with X-ray
6 months.....	7	17	1	1
6 mo. to 1 yr.....	3	4	..	2
1 to 1½ yr.....	2	7	..	..
1½ yr. to 2 yr.....	5	5	1	..
2 to 2½ yr.....	..	..	..	..
2½ to 3 yr.....	..	2	..	..
3 to 3½ yr.....	1	3	..	..
3½ to 4 yr.....	..	2	..	..
4 to 4½ yr.....	1	1	..	..
4½ to 5 yr.....	..	1	..	..
5 to 5½ yr.....	1	..	..	..
5½ to 6 yr.....	..	..	1	..
Total of 68 cases.....	..	..	..	..

### CONCLUSIONS

We feel that x-ray irradiation has become an important adjunct in the treatment of carcinoma of the breast. Our experience in preoperative treatment has been limited to a few cases during the last year and one in the preceding ten year period covered in this analysis. Stage III, we believe, is the most important group in which irradiation before surgery is given although results are, as yet, too recent to publish in this paper. Ablation of the ovaries in premenopausal patients, especially those individuals in their third and fourth decades with tumors in Stages I, II, and III, is now based on long standing biological facts.<sup>2</sup> Where it is possi-

ble we suggest that it be a temporary procedure but the uncertainty of this x-ray dosage often makes it permanent. In this end result by irradiation our purpose has been defeated by two important factors which are worthy of consideration: (1) maternal instinct and sincere desire for continued fertility and ability to procreate; (2) religious obstruction.

During the period 1925 to 1929 inclusive (fifty-two cases) only eighteen received postoperative irradiation and a single case had preoperative x-ray treatment. In the rest of the series 1930 to 1935 (125 cases) all but four patients received a postoperative series. Of the four only one had a distinct contraindication, i.e., pulmonary tuberculosis. All patients with resectable lesions are now receiving x-ray after surgery. Several times we have noted recurrences five to ten years after operation in patients who had small lesions and received no x-ray therapy.

Stage iv and iva patients, unless they are hopelessly riddled with metastatic lesions, are thought to be worthy of irradiation. One particular patient in the past two years entered the hospital as a stage iva with bilateral pleural effusion. The pleural fluid revealed cancer cells. Besides this she had almost a complete collapse of D<sub>12</sub>. She was given a series of treatments, had several thoracenteses and was fitted with a Taylor back brace. Three months later a simple mastectomy was done and the spine was irradiated. By religious x-ray treatment her life was prolonged two years and without the suffering often used as an excuse for not treating late cases.

An outline of the general principle followed in the postoperative irradiation of carcinoma of the breast is somewhat as follows:

In cases where the growth is definitely limited to the breast a three field technique is used. The anterior breast area extends from the clavicle to the level of the diaphragm and from the midsternal line to the midaxillary line. The supraclavicular field is limited by the superior border of the clavicle, the medial border of the sterno-

mastoid muscle and the superior border of the trapezius. The limitations of the axilla are well known.

The physical factors used may be summarized in this manner. The anterior breast area receives 200 r, measured in air, at 100 Kv. 5 ma. 30 cm. HVL cm. 0.14 mm. for a total dosage of 1200 r. The supraclavicular and direct axilla each receive 200 r, measured in air, at 160 Kv. 7.5 ma. 30 cm. HVL cm. 0.85 mm. for a total of 1200 r. A second series of treatments is given after three months, a third, fourth and possibly a fifth series after four months interval.

When the axillary nodes are involved or suspected of involvement, a modification of the above procedure is followed. Instead of irradiating the axilla through one portal, two portals are used, one through the anterior axillary fold and the other through the posterior axillary fold, with the same physical factors as in the one portal technique. In addition, the total dosage of the initial series is increased to 1600 r to all areas, but in subsequent series, a total of 1200 r is given.

This plan is not hard and fast, but is variable according to the demands of each individual case.

#### SUMMARY

In the differential clinical diagnosis of mammary neoplasms, adenocarcinoma can safely be excluded only after biopsy and microscopic study.

In a series of 177 cases of mammary cancer treated by surgery with x-ray therapy, 30.4 per cent of the patients are alive three years or more after treatment; 18 per cent five years or longer.

Only one of every four patients presents herself with a lesion still within the breast. Exclusive of Group I this results in a cure in 86.1 per cent in Group II and 15.4 per cent in Group III. The mortality rate then increases five and one-half times as spread occurs beyond the breast.

The results of irradiation therapy for curative purposes in recurrent or metastatic mammary adenocarcinoma are poor.

PERCENTAGE OF CURE BY STAGES

Stage	Patients Treated	Per Cent Cures
I.....	1	100.0
II and IIa.....	40	86.1
III and IIIa.....	130	15.4

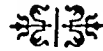
The indications for simple mastectomy in carcinoma of the breast irrespective of the stage of the tumor have been presented.

If for no other indication than to give the patient the benefit of all possible cura-

tive therapy, we shall continue to use irradiation therapy with surgery in the treatment of all operable mammary carcinomas.

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USUALLY biopsy should not be performed unless the surgeon has facilities to have the tissue examined by the pathologist grossly or microscopically while the patient is on the operating table and is prepared to proceed immediately with the radical operation if the tissue examined reveals malignancy.

From—"Minor Surgery" by Christopher (Saunders).

# SURGICAL TREATMENT OF GASTROINTESTINAL HEMORRHAGE

LEONARD K. STALKER, M.D.\*

AND

HOWARD K. GRAY, M.D.

Fellow in Surgery, The Mayo Foundation

Division of Surgery, The Mayo Clinic

ROCHESTER, MINNESOTA

THE surgical treatment of gastrointestinal hemorrhage is frequently a debatable and difficult problem from the standpoint of successful management. We propose to mention a few of these problems and to consider briefly some of the surgical procedures employed in their treatment. The conditions that cause hemorrhage can be divided anatomically into gastroduodenal and extragastroduodenal. In more than 75 per cent of cases,<sup>1</sup> gastrointestinal hemorrhage is due to the gastroduodenal group of conditions, and for this reason we shall be concerned chiefly with this group.

Of primary importance, before one contemplates operation for any gastroenteric hemorrhage, is an accurate diagnosis; for, with the exception of a few conditions, such as purpura hemorrhagica, mesenteric thrombosis, intussusception, volvulus and certain cases of peptic ulcer, the immediate remedies that should be employed are entirely medical. If doubt exists as to the diagnosis, it is usually the best policy to treat the patient conservatively.

## PEPTIC ULCER

By far the most common source of hemorrhage in the gastroduodenal group is a peptic ulcer. It is generally agreed that 12 to 20 per cent of patients who have peptic ulcer have gross hemorrhage and the reported mortality in their treatment by conservative means varies from 1 to 25 per cent.<sup>2</sup> Some authors advocate the immediate surgical treatment of all bleeding peptic ulcers. Finsterer has stated that operation during the first forty-eight hours carries a mortality of less than 5 per cent, but that after forty-eight hours this increases to 30 per cent. Others feel that

when adequate conservative treatment is employed the mortality will be less than 5 per cent and therefore immediate operation is only rarely justified.

*Indications for Surgical Intervention.* There are a few cases, however, in which immediate operation should be employed, but the selection of these is difficult. All patients who have gastrointestinal hemorrhage due to peptic ulcer should be seen immediately by both surgeon and internist, and certain factors should be considered; namely, what is the patient's general condition, is he in a state of collapse and exsanguinated? Has he had a severe massive hemorrhage or is the bleeding slowly and progressively going on? One helpful point in this regard is to note whether or not the vomitus is bright red and alkaline, or coffee-ground and acid. The former is indicative of a profuse and rapid process and the latter of a comparatively slow one. The patient's age is of importance, as Goldman has estimated that patients more than 40 years old are more than 70 per cent more likely to die than those under 40. Allen's series showed a mortality of 33 per cent for patients more than fifty years of age, as compared with a mortality of 4.4 per cent for patients less than fifty years of age.

The presence of arteriosclerosis is an important factor. In various series, approximately 70 per cent<sup>3</sup> of those patients who have died have shown gross arteriosclerosis. Women are less likely to have peptic ulcer than men, but those women who do are equally prone to bleed profusely. Women seem also more likely to have spontaneous remissions. Among patients whose concentration of hemoglobin is less than 60 per

\*Now residing in Rochester, New York

cent<sup>s</sup> the mortality rate is four times greater than that among those whose concentration of hemoglobin is greater than 60 per cent (Dare). In general, two or more gross hemorrhages may mean that further recurrences are in store and after the second hemorrhage an abrupt rise in the mortality rate occurs.

Assuming that an operation be performed, what is the possibility of arresting the hemorrhage with certainty? Is the peptic ulcer in the stomach or duodenum? Is it acute or chronic? The presence of the hemorrhage itself adds greatly to the technical difficulties and may make it impossible to locate the lesion. Prior to operation it is an arbitrary point as to whether a gastric or duodenal ulcer is present. If a gastric ulcer is present, it may be irremovable because of its situation. Even if the ulcer can be identified, its situation and surroundings may not allow efficient ligation of the bleeding points. If the source of bleeding is due to an acute ulcer, gastritis, or duodenitis, the source may be identified only after opening the stomach and duodenum.

When these factors have been considered, even though the patient has a peptic ulcer and other possible causes for hemorrhage have not been found, the question of operation is still difficult. It is likely that, if the patient is less than 50 years of age and has elastic vessels, conservative measures are, temporarily at least, indicated. If, however, the patient is more than 50 years of age, has an apparent degree of arteriosclerosis and at the same time is a fair surgical risk, operation must be seriously considered. If under conservative treatment the bleeding continues, and if the hemoglobin cannot be controlled by multiple transfusions, a surgical attack on the ulcer is sound treatment. In other cases, in which the ulcer has caused an erosion of some large vessel or a concomitant hemorrhage and perforation, operation is imperative. Hemorrhage in a case in which there is recent roentgenographic evidence of an ulcer on the posterior wall of the duodenum, or pyloric or

duodenal stenosis, frequently justifies operation. Surgical treatment must be considered when a second hemorrhage occurs soon after the first, or when the patient relates a long, definite history of ulcer and has a fibrotic ulcer.

*Surgical Treatment.* The surgical procedure employed will vary with the type and site of the ulcer, the condition of the patient and the skill of the particular operator. If a gastric ulcer is found, either gastric resection or some form of an excision with a gastrojejunostomy may be done. If the operation is one of emergency, however, only ligation of the bleeding vessels may be justified. These vessels must be ligated in healthy tissue, outside the wall of the stomach. They can best be ligated by opening the normal anterior wall of the stomach, so that the region from which bleeding occurs can be visualized and compressed during ligation of the anastomosing branches. When this is accomplished, the opening in the wall of the stomach is closed and a resection is carried out at a later date.

If the ulcer is duodenal, several methods of treatment may be employed. Occasionally, the duodenal ulcer may be excised and a gastroenterostomy performed. This procedure is most desirable for patients more than 50 years of age, and for those who have an ulcer on the anterior wall. If the ulcer is on the posterior wall of the duodenum, as is usually the case, several methods must be considered. The radical operation of gastroduodenal resection with excision of the ulcer is to be preferred if there is little inflammatory reaction and if the patient's condition permits. More frequently than not, considerable induration and inflammation may make a radical gastroduodenal resection impossible. A gastric resection down to the pylorus, thus excluding the ulcer, is feasible in these cases. One can neither open the anterior wall of the duodenum and successfully place ligatures in the friable bed of the ulcer nor safely pass stitch ligatures in such a way as to occlude the vessels in healthy tissue from within.



The superior pancreaticoduodenal artery is usually the artery involved in the hemorrhage, but due to the diffuse arterial anastomoses behind the duodenum, it is unlikely that bleeding can be controlled except by ligation of the right gastroepiploic artery and the superior and inferior pancreaticoduodenal arteries. Allen and Benedict transect the prepyloric end of the stomach, elevate the duodenal end and separately ligate the blood vessels outside the duodenum before the ulcer is approached. Others propose an under-running and ligation of the blood vessels in the region of the pylorus and of the first part of the duodenum. Some surgeons open the pylorus and anterior wall of the duodenum for exposure and then cauterize or otherwise obliterate the ulcer. The anterior wall of the duodenum may be infolded in such a manner as to produce stenosis and plugging of the bed of the ulcer, or the pylorus may be occluded with a heavy suture. A posterior gastroenterostomy is to be performed as an adjunct to these procedures. In other cases pyloric exclusion with a gastroenterostomy may be done, or occasionally a gastroenterostomy alone. As a rule, however, any indirect operation without a direct attack on the ulcer will fail.

When the hemorrhage ceases, or subsides under conservative treatment, the problem of surgical treatment is debatable. If the patient is young and responds well to a dietary regimen, we may justly feel that a radical operative procedure is unnecessary. If the patient is more than 50 years of age, or has had several hemorrhages, some surgical procedure usually should be carried out. It is probable that the greatest protection can be obtained from the more radical procedure, although in certain cases a simple gastroenterostomy will protect the patient against recurrent and, at least, fatal hemorrhage.

*Gastrojejunal Ulcer.* A few patients who have had a gastroenterostomy performed, experience an acute massive hemorrhage associated with a stomal ulcer. The inflammatory process may involve and erode a

large vessel such as the gastroepiploic or the colic arch. This presents a difficult surgical problem because it is necessary to take down the old anastomosis in order to find the bleeding ulcer, and if such a procedure is to be done, it must be done early. An acute massive hemorrhage from a stomal ulcer is uncommon, although in 35 per cent of such cases,<sup>10</sup> the ulcers do bleed. When such a hemorrhage occurs, it is usually slow and progressive, and it is best treated conservatively until the patient's condition warrants operation.

#### GASTRIC CARCINOMA

Gastric carcinoma is frequently the cause of gastrointestinal bleeding, but is rarely the cause of a massive hemorrhage. If a patient is known to have a carcinoma of the stomach, and has an acute massive hemorrhage, the advisability of performing an immediate resection must be considered, as it may require weeks, or even months, to overcome the effects of this serious hemorrhage.

#### POSTOPERATIVE HEMORRHAGE

Postoperative hemorrhage in cases in which some surgical procedure has been performed on the stomach or duodenum, is usually best treated by conservative measures. Occasionally, however, in spite of conservative therapy, the patient's condition may necessitate reoperation. If a posterior gastroenterostomy has been performed, one of two procedures may be employed. The anterior wall of the stomach may be opened, the anastomosis may be pulled up through this opening, and if one or two single bleeding points are seen, they are controlled by sutures. However, a general oozing is more frequently present; in which case it is better to oversee the entire circumference of the gastroenterostomy. An alternative method is to remove the anterior row of sutures of the anastomosis, thus visualizing the posterior row. The bleeding is controlled and the anastomosis remade. To make other types of anastomoses, it is

usually necessary to take down a portion of the anastomosis in order to visualize the bleeding points. If, in the previous operation, the original ulcer was not dealt with and if, after examination of the line of suture, it is obvious that this is not the source of the hemorrhage, a direct attack on the bleeding ulcer must be considered.

#### MISCELLANEOUS SOURCES OF HEMORRHAGE IN THE GASTRODUODENAL GROUP

Gastric polyposis, gastritis, duodenitis, syphilis and certain benign tumors of the stomach have been reported in isolated instances as causes of acute massive hemorrhage. This is unusual, but when it does occur, it should probably be treated during the acute phase conservatively, and operation should be performed during the interval.

Varices of the esophagus may cause acute massive hemorrhage; approximately 5 per cent<sup>10</sup> of the deaths in cases of portal cirrhosis are due to hemorrhages from this source. Emergency operation cannot be recommended in these cases. When the diagnosis is in doubt, one is justified in carrying out roentgenologic examination of the esophagus. Occasionally, during splenectomy, or some other surgical procedure, it is advisable to attempt ligation of some of these varicosities, or to ligate the coronary vein. Some have injected sclerosing solutions directly into these veins, but in the majority of instances surgical treatment is not satisfactory.

#### MISCELLANEOUS SOURCES OF HEMORRHAGE IN THE EXTRAGASTRODUODENAL GROUP

Gastrointestinal hemorrhage is a frequent complication of certain forms of splenic disease, namely splenic anemia, or Banti's disease, and thrombocytopenic purpura. Hemorrhage is seen in the late stages of nearly every case of splenic anemia. A splenectomy should be performed as early as possible in the course of the disease, but operation should not be performed during or just after a hemorrhage, but usually

during the interval when the patient is the best operative risk.

Rather dramatic results may be obtained by performing a splenectomy during the active hemorrhagic state of thrombocytopenic purpura. Pemberton said: "In the absence of an associated condition which would constitute a definite contraindication, it is my conviction that unless the course of the disease is checked by one or possibly two transfusions of blood, splenectomy should be done without further delay, for the risk of tiding these patients over the acute exacerbation is often greater than that of operation during the early phase of the crisis of the disease."

Meckel's diverticulum and solitary ulcers of the ileum may occasionally be the source of rather puzzling gastrointestinal hemorrhage. It is estimated that 2 per cent of the entire population have a Meckel's diverticulum, but only one-fourth of these show some pathologic change.<sup>5</sup> The diagnosis of either of these conditions can be made only by exclusion. It is important to remember that this condition exists and to look for it on abdominal exploration.

Three conditions that constitute emergencies should be mentioned briefly. They are mesenteric embolism and thrombosis, volvulus, and intussusception. Intussusception is rare in adults, but should always be suspected in infants when fresh blood is passed from the rectum. The same may be said to apply to volvulus in adults. A vascular accident to the mesenteric vessels may cause rapid effusion of a large amount of blood into the bowel. Embolism of the artery and thrombosis of the veins are rare, but the former should be suspected in cases of advanced rheumatic heart disease or subacute bacterial endocarditis. If the diagnosis is made early, a resection may be performed.

A difficult problem is presented when a patient has recurring hemorrhages, the cause of which cannot be established definitely because of the absence of other symptoms, and because of negative or inconclusive findings on roentgenologic study

of the gastrointestinal tract. Exploration should be advised in such cases. A lesion of the duodenum frequently is discovered, usually on the posterior wall and farther from the pylorus than such lesions commonly occur. If the stomach and duodenum appear normal, and further exploration fails to reveal a satisfactory cause for the bleeding, one is justified in opening the stomach or duodenum so that a more accurate examination can be made. The other abdominal viscera such as the gall-bladder and appendix should be examined carefully to make certain that some other pathologic lesion that could account for the bleeding is not present. If any such condition is present, the surgeon should not hesitate to deal with it radically.

The majority of the common causes of gastrointestinal bleeding have been mentioned. Many other conditions, such as lesions in the large intestine, rupture of an aneurysm, acute toxic states with erosion of the stomach, congestive heart failure, duodenal carcinoma, syphilis, vicarious menstruation, tuberculosis, primary blood dyscrasias, trauma, vitamin deficiency, hemorrhagic diathesis and so forth, could be considered. The surgical treatment of

gastrointestinal hemorrhage is usually indicated by the diagnosis.

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# AN OPERATION FOR THE REPAIR OF DIASTASIS RECTI ABDOMINIS\*

SAMUEL A. ROMANO, M.D.

Assistant Professor of Surgery, Louisiana State University School of Medicine

NEW ORLEANS, LOUISIANA

THE various methods employed at present in the repair of diastasis of the recti abdominis muscles give a fairly high percentage of successful results, but are followed by recurrence of the original weakness in a certain number of cases. The search for new methods of repair therefore still continues.

The purpose of this communication is to describe a technique which I have used with increasing satisfaction for the last three years in cases in which the diastasis extends above the linea semicircularis, that is, above the inferior termination of the posterior rectus sheath. Although the attenuated anterior and posterior rectus sheaths, transversalis fascia, and peritoneum above the linea semicircularis are of themselves insufficient for support of the mid-abdominal wall in such cases, in many instances these structures may be utilized to form two of the layers of an adequate three-layered closure, the third of which is muscle. (Fig. 1E.)

The use of this technique requires a preliminary consideration of the anatomy of the rectus sheath, which differs above and below the linea semicircularis. Above the linea semicircularis the rectus sheath is formed by the aponeuroses of the external oblique, internal oblique, and transversus abdominis muscles as follows:

At the lateral edge of the rectus muscle the aponeurosis of the internal oblique divides into two layers, one of which passes in front of the rectus muscle and fuses with the aponeurosis of the external oblique, while the other passes behind the rectus muscle and fuses with the aponeurosis of the transversus abdominis. The aponeuro-

ses of all these muscles fuse at the medial border of the rectus, where they are inserted into the linea alba. The posterior sheath of the rectus muscle extends from the margins of the costal cartilages inferiorly to a level about midway between the umbilicus and the symphysis pubis. The inferior termination of the posterior rectus sheath is referred to as the linea semicircularis. Below this level the muscle lies directly upon the transversalis fascia, without a posterior sheath, and the aponeuroses of the external and internal oblique muscles and of the transversus abdominis all pass in front of it to form its anterior sheath. The thickness of the anterior sheath is therefore greater below than above the linea semicircularis.

## TECHNIQUE

The operation to be described differs from other procedures devised for the repair of diastasis of the recti abdominis muscles in the method of utilization of the fascial structures. It is performed as follows:

A midline incision is made over the entire extent of the separation of the recti muscles, extending slightly beyond the diastasis at each end. The umbilicus is excised. The rectus sheaths are exposed, the dissection being carried back on the right side to a point at which the rectus muscle can be palpated. On the left side the dissection is carried only far enough back from the midline to allow sufficient room for suture of the medial edge of the sheath on that side.

The linea alba and the peritoneum are opened in the midline over the entire extent of the separation of the muscles. By careful

\* From the Department of Surgery of the School of Medicine, Louisiana State University, and Charity Hospital of Louisiana, at New Orleans.

inspection and palpation it is then determined whether the combined fascial layers will be sufficiently strong to serve as a

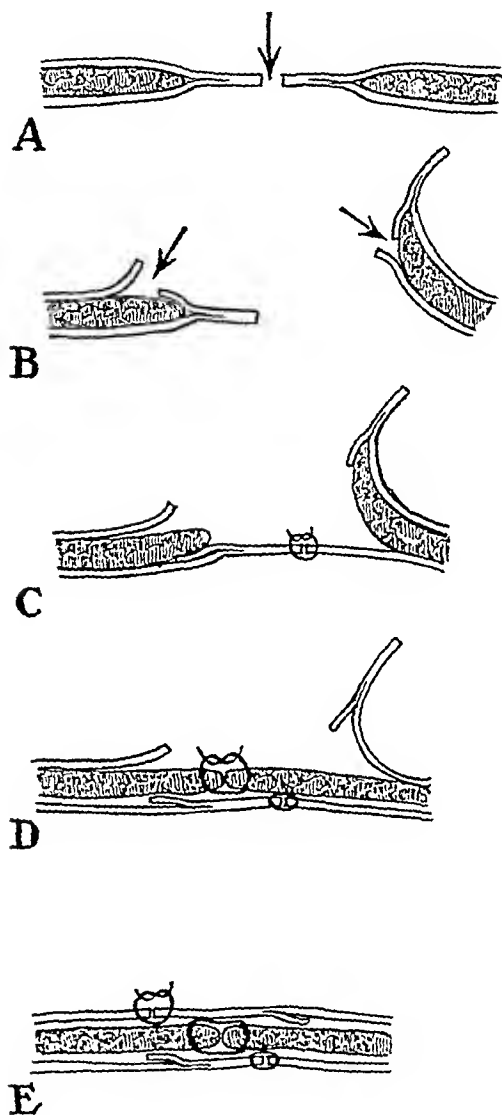


FIG. 1. Diagrammatic cross sections showing method of obtaining the flaps and their use in the closure of the diastasis. A, midline incision through the attenuated rectus sheaths, transversalis fascia, and peritoneum. B, incisions into the anterior rectus sheath on the right side and into the posterior rectus sheath on the left. C, approximation of long and short posterior flaps. D, approximation of posterior flaps and rectus muscles. E, approximation of anterior flaps, muscles, and posterior flaps. Note relations of the suture lines to each other in the three layers of the closure.

single layer in the closure. If the technique seems applicable in the special case, the

right anterior rectus sheath is incised to permit entry into the compartment occupied by the rectus muscle, the distance of the incision from the midline being determined by the amount of tightening or bracing of the abdominal wall that seems necessary.

The incision in the right anterior rectus sheath is then enlarged upward and downward, parallel to the midline incision, but curving toward it at the extreme upper and lower ends. If the separation of the rectus muscle extends below the linea semicircularis, the incision in the rectus sheath curves toward the midline at that level. The anterior sheath is freed from the muscle as necessary.

When the dissection is complete, a long posterior flap has been provided, consisting of a portion of the anterior rectus sheath plus the intact posterior sheath, transversalis fascia, and peritoneum. A short anterior flap is also provided, consisting of the anterior sheath of the rectus muscle. (Fig. 1B.) The long posterior flap is always made on the right side, as it is desirable to have the round ligament of the liver included in it.

The left edge of the wound is now turned outward, so as to expose the inner side of the peritoneum. An incision is made from the peritoneal side through the peritoneum, transversalis fascia, and posterior sheath of the rectus muscle into the compartment occupied by the muscle. (Fig. 2.) The incision is continued upward and downward parallel with the midline incision, as on the right side, and is curved in the same way toward the midline at either end. There have now been provided on this side a long anterior flap, consisting of a short portion of peritoneum, transversalis fascia, and posterior rectus sheath, plus the intact anterior rectus sheath, and a short posterior flap, consisting of the posterior sheath of the rectus muscle, transversalis fascia, and peritoneum. (Fig. 1B.)

If the original midline incision does not extend below the linea semicircularis, the two flaps described are continuous above and

below with the linea alba. If it extends below the linea semicircularis, the long posterior flap is continuous inferiorly with the trans-

Interrupted sutures are next placed in the muscles which have been freed during dissection of the flaps, but are not tied at

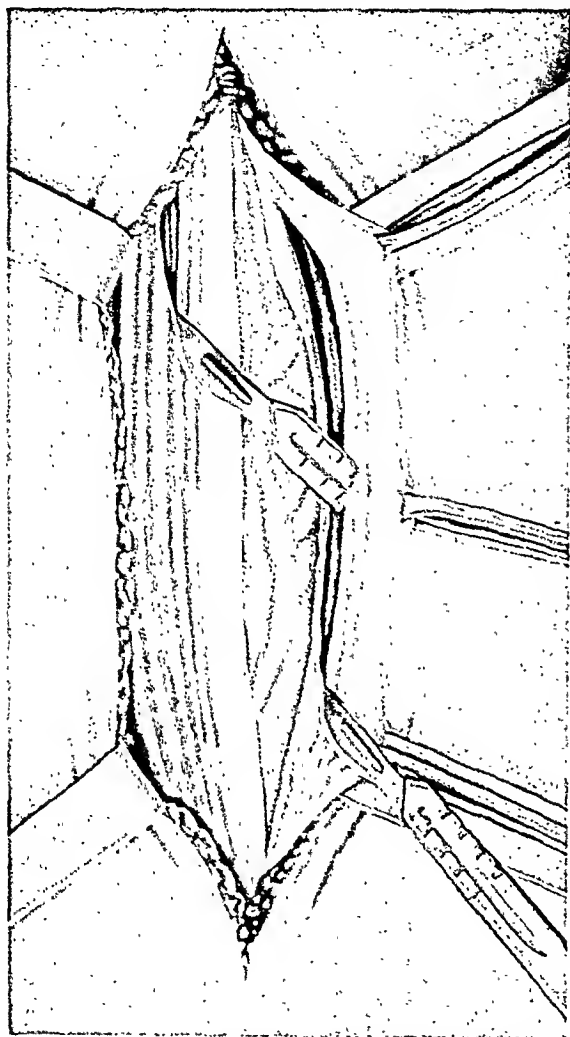


FIG. 2. Peritoneal cavity opened in the midline. Incisions are made into the right rectus sheath anteriorly and into the left rectus sheath posteriorly.

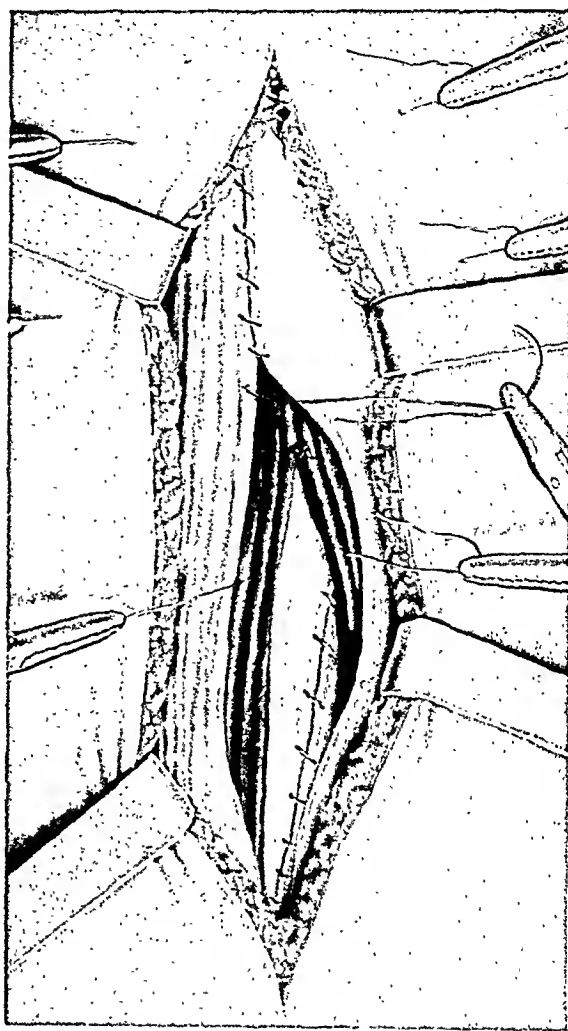


FIG. 3. Approximation of long and short posterior flaps. Interrupted muscle sutures and two retention sutures in place. Continuous suture of long and short anterior flaps has been begun. (Some of the interrupted muscle sutures and retention sutures have been omitted in the drawing to make the demonstration clearer.)

versalis fascia and peritoneum, and the long anterior flap is continuous inferiorly with the anterior rectus sheath.

In the closure of the incision, the first suture line is begun in the linea alba at the upper end of the incision. The long posterior flap is sutured to the short posterior flap (Fig. 1C) by sutures so placed as to appose the peritoneal surfaces and continued until the incision is completely closed. When the diastasis extends below the linea semicircularis, the suture line is continued below that level, but the sutures are placed only through the peritoneum and transversalis fascia.

this time. (Figs. 1D and 3.) If it is thought desirable to use retention sutures, they are placed from within outward through the anterior rectus sheath and the skin.

The third line of closure is started in the linea alba at the upper angle of the incision, just beyond the point at which the first layer of sutures was started. This suture line is continued downward to unite the long anterior flap and the short anterior flap. (Figs. 1E and 3.) When the separation extends below the linea semicircularis, the suture line is continued below this level to

approximate the right and left anterior rectus sheaths, which should be overlapped sufficiently far to obtain the desired amount of tightening in the lower part of the abdomen. The interrupted sutures already placed in the muscles are tied as they are reached.

#### COMMENT

The technique described for the closure of diastases of the recti abdominis muscles has been used in eleven cases, which have been followed up for periods ranging from six months to three years. The results have been entirely satisfactory and there has been no evidence of recurrence in any case.

This method of repair possesses several distinct advantages. It can be used with safety as a supplementary procedure in operations undertaken primarily for other

purposes, because it adds very little to the time required for simple incisions and closures of similar extent. I have personally used it in operations undertaken for surgery of the biliary tract and the pelvic organs, and have encountered no difficulties in the performance of the combined operations.

All the fascial structures are employed in the closure, which is therefore as strong as it could possibly be. An additional safeguard lies in the fact that the approximation of each fascial layer is done at a different point (Fig. 1E), so that the strain of intra-abdominal pressure is widely distributed. The technique is logical from the anatomic point of view, and permits a closure more nearly approximating normal anatomic restoration than is possible in any other procedure for this purpose which has come to my attention.



# ACUTE APPENDICITIS IN DIABETES MELLITUS\*

AARON NEIMAN, M.D.

CHICAGO, ILLINOIS

THE diagnosis and treatment of acute appendicitis in diabetic patients is a serious problem because of the presence of a metabolic disease as an associated factor at the outset. The two conditions existing together have a bad influence on each other. While an early diagnosis of acute appendicitis is always desirable, it is particularly important in diabetic patients. In mild diabetics under treatment, the diagnosis in typical cases is no more difficult than in non-diabetics, other things being equal. In the severe cases, especially those not under treatment, the diagnosis may be more difficult and the surgical intervention rather late. Early removal of an acutely infected appendix is more urgent in a diabetic than in a normal person for two reasons: first, the infection quickly aggravates the diabetic condition; second, the infection does not remain localized long. In addition, we must consider that patients in acidosis are encountered in whom acute appendicitis is either suspected or actually present, and that acidosis itself often gives rise to diffuse abdominal pain, tenderness, and vomiting.

Recent personal experience with two cases at the Mt. Sinai Hospital, Chicago, prompted me to review the subject. The hospital records were searched for cases of acute appendicitis in diabetic material from January 1, 1929 to January 1, 1939. During this time 1,251 diabetic patients were admitted to the hospital for various ailments. Acute appendicitis occurred eight times. Seven of the eight were complicated at the time of operation by gangrene, perforation, abscess formation, or peritonitis. Two had gangrene, two had abscess formation, three had peritonitis. Of the last group, two died postoperatively. One patient had acute ca-

tartral appendicitis. One had acute clinical symptoms but pathologically the appendix was not acutely inflamed; this case is not considered in this paper.

With the exception of one case, the patients were in the elderly age group, the ages being, 14, 47, 49, 50, 55, 55, 60, and 63, respectively. There were six females and two male patients. Heart disease, hypertension, arteriosclerosis, and obesity were associated factors.

Bothe and Bearwood<sup>1</sup> reviewed 1,260 cases of diabetes mellitus admitted to the Pennsylvania Hospital. In this series of cases there were seven instances of acute appendicitis, and of these four were ruptured at the time of operation. These authors emphasize the difficulty at times of an early diagnosis and proper evaluation of abdominal symptoms in a diabetic patient with an acute surgical lesion. In their material, 136 patients of 1,260 studied had diabetic acidosis, and of these "74 per cent presented abdominal symptoms of nausea, vomiting and abdominal pain which were usually associated with fever and leucocytosis."

McKittrick and Root<sup>2</sup> make this terse statement on the subject in their book on diabetic surgery: "Acute appendicitis is especially dangerous in a diabetic because the symptoms and signs may be obscure, the diagnosis difficult and the treatment late." In the fourteen cases of acute appendicitis listed in their book, six were ruptured and four gangrenous, i.e., ten in fourteen were complicated at the time of operation.

McKittrick<sup>3</sup> reports thirty-seven operations for appendicitis in which twelve required drainage. Of these twelve six cases had drainage of abscess with or without spreading peritonitis. The mortality in the

\* From the Medical and Surgical Service, Mt. Sinai Hospital, Chicago, based on a review of 1,251 diabetic patients from January 1, 1929 to January 1, 1939.



last six cases was 33.3 per cent, while the total mortality was 6.1 per cent.

TABLE I  
RELATIVE FREQUENCY OF CLINICAL SYMPTOMS ON  
ADMISSION

Onset sudden.....	6
Onset insidious.....	2
Pain in right lower quadrant.....	8
Tenderness in right lower quadrant...	6
Rebound tenderness in right lower quadrant.....	3
Muscle spasm or rigidity.....	5
Pain in lower half of abdomen.....	3
Nausea.....	1
Vomiting.....	0
Temperature.....	8
Leucocytosis.....	7
Appeared acutely ill.....	3
Distention of lower half of abdomen..	4
Mass in right lower quadrant.....	2
Acidosis present.....	2

*Signs and Symptoms.* Table I shows that abdominal pain with localization in the right lower quadrant, local tenderness, muscle spasm or rigidity, temperature, pulse of 100 to 120, and leucocytosis form

the signs and symptoms of acute appendicitis in the group reviewed. Nausea and vomiting were conspicuously absent.

The onset was sudden in six and insidious in two cases, although McKittrick and Root<sup>2</sup> claim that the onset is generally insidious in acute appendicitis in diabetic persons. All had an elevated temperature and pulse. All but one had leucocytosis; in this patient the white count was 9,900 and differential 79 per cent. Ruptured appendicitis with peritonitis was present. Those who had pain in the lower half of the abdomen (right more than left), distention, and temperature of 101 to 102°F., suffered from ruptured appendicitis with peritonitis. Of the two patients with masses in the right lower quadrant, in one there was spontaneous rupture into the rectum. The other was drained. Recovery followed in both cases.

In the three cases of peritonitis, the extent of the pathologic process was in a

TABLE II\*

R.B.C.	W.B.C.	Neutrophils, Per Cent	Hgb.	Urine Sugar	Blood	Temp. Rectal	Pulse	Laxative
5,100,000	17,400	82	90	2.5% A+++	147	102.2	110	Enema
4,000,000	13,100	84	72	1.6%	221	102.8	120	No mention
.....	17,300	87	?	+ A++++	181	100.2	100	Yes
4,300,000	9,900	79	?	3.8% A++	286	102.4	100	Yes
3,900,000	17,800	82	75	+ A	195	100.6	115	No mention
4,000,000	17,000	79	?	3.3% A+	251	101.2	108	Yes
.....	26,650	83	?	5% A+++ D+	371	102.4	116	Yes
.....	14,200	88	?	4% A++ D+	286	101	110	Enema

\* A = Acetone

D = Diaacetic acid

clinical sense underestimated. One patient, in whom there was a tendency to localize in the right lower quadrant and pelvis recovered, but had extensive wound infection with slough of fascia; the other two died shortly after operation. In two cases of appendiceal abscess there was a positive diacetic acid test. These were in acidosis.

Therefore, the diagnosis of acute appendicitis in a diabetic person may be based on a history of abdominal pain which localizes in the right lower quadrant, local tenderness and muscle spasm, temperature 100 to 101, or even 102, elevated pulse, leucocytosis. Likewise, appendiceal symptoms with pain and distention in the lower half of the abdomen should give a suspicion of peritonitis.

A differential diagnosis between acute appendicitis and acidosis with abdominal symptoms simulating a surgical lesion may be a difficult problem. In appendicitis the onset is rather sudden and pain and tenderness are localized to the right lower quadrant, unless abscess or peritonitis is a complication. In acidosis, the onset is usually insidious and pain and tenderness are likely to be diffuse. With insulin therapy, the symptoms in acidosis will clear up or become milder in three to six hours, whereas in appendicitis the symptoms remain the same or get worse as one waits. A positive diacetic acid test is characteristic for acidosis and in its absence one is fairly safe in saying that acidosis does not exist. Blood sugar and carbon dioxide combining power of blood plasma will help in difficult cases to establish proper diagnosis. Finally, if clinical symptoms point to acute appendicitis and there is no mitigation of symptoms after insulin therapy, prepare the patient for surgery.

*Pre- and Postoperative Care.* The decision as to the urgency of immediate operation is of vital importance. The immediate preoperative and postoperative care consisted in most instances of insulin subcutaneously based on urinary analyses for sugar, acetone, diacetic acid, and infusion of physiologic salt solution and 5 per cent glucose.

Opinions differ as to the needs of glucose immediately before and after surgery. Earlier writers on the subject, Jones, McKittrick, Sisco,<sup>4</sup> and Walter, Myerding, Judd, Wilder<sup>5</sup> favored insulin subcutaneously and salt solution preferably by the hypodermoclysis route. Woodyatt<sup>6</sup> is also of the opinion that glucose is not needed immediately before surgery. The reason given by him is that the patient already has enough glucose which he cannot utilize.

Standard and his associates<sup>7</sup> state that he gives for all major surgical procedures an infusion of 1000 c.c. of physiologic salt solution of sodium chloride with 50 Gm. of dextrose two hours before operation and repeats this postoperatively in all moderately severe cases.

TABLE III

Sex	Age	Postoperative Diagnosis	Operation	Anesthesia
M	63	Acute gangrenous appendicitis.	Appendectomy. No drainage.	General and novocaine.
F	60	Acute gangrenous appendicitis; pelvic peritonitis.	Appendectomy. Drainage. Extensive wound infection and sloughing of fascia.	Novocaine only.
F	14	Acute catarrhal appendicitis.	Appendectomy. No drainage.	Nitrous oxide and ether.
M	49	Acute ruptured appendicitis; generalized peritonitis.	Drainage of abdomen. Died after generalized peritonitis and pneumonia.	Novocaine and ethylene.
F	47	Acute gangrenous appendicitis.	Appendectomy. No drainage.	Novocaine and ethylene.
F	55	Acute appendicitis; peritonitis; acute diffuse appendicitis and periappendicitis.	Appendectomy. Drainage. Died after generalized peritonitis and pneumonia.	Novocaine and nitrous oxide.
F	55	Appendiceal abscess.	Drained abscess. Infected wound.	Nitrous oxide.
F	50	Appendiceal abscess.	Refused operation. Spontaneous rupture into rectum. Recovered.	No operation.

## COMMENT

In some of the cases reviewed especially those admitted at night, the diabetic condi-

tion was a definite factor in causing delay in operation. Both of the fatal cases arrived at the hospital at night and operation was delayed until the next day because of the diabetic condition. Some practical points may be made. These have been gathered from the literature.

1. The aim should be to remove the infected appendix first, and to treat the diabetes later.

2. It is not necessary to wait until the urine is sugar free. Small amounts of sugar in the urine do no harm at the time of operation and depletion of carbohydrate is less likely to occur. The glycogen present in liver acts as a protective agency.

3. Blood sugar and  $\text{CO}_2$  determinations may be done if facilities are present, but these are not imperative in an emergency, provided urine is examined for sugar, acetone and diacetic acid. Insulin is given accordingly.

4. The diacetic acid test is a reliable and satisfactory index of acidosis in surgical emergencies. It is simple to do, and can be readily repeated day or night. This test can be used as a diagnostic and therapeutic guide. If negative, operation does not have to be delayed. If positive, give 40 to 60

units of insulin and saline, and repeat the test in three to four hours. As soon as the patient is out of acidosis, operate.

5. Consultation with a medical man interested in diabetes is wise.

#### CONCLUSIONS

In the majority of instances of acute appendicitis in diabetes, patients come to surgery with complications of gangrene, perforation, abscess formation, or peritonitis. Delay in operation is more dangerous than in normal persons.

The diacetic acid test is a reliable and satisfactory index of the presence or absence of acidosis in acute surgical emergencies.

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# THE SURGICAL TREATMENT OF ACUTE CHOLECYSTITIS\*

H. K. BONN, M.D., F.A.C.S.

AND C. A. BACHHUBER, M.D., F.A.C.S.

Assistant Professor of Surgery, College of  
Medical Evangelists

Instructor of Surgery, College of Medical  
Evangelists

LOS ANGELES, CALIFORNIA

CAVE has aptly stated that sound judgment is required to choose the opportune moment for surgical intervention in acute cholecystitis and that any attempt to standardize the time of operation is hazardous. An early operation, as defined by Cave, implies an interval of from twenty-four hours to seven days, while a delayed procedure is one done after the acute process has subsided, a matter of weeks or even months. Likewise surgeons may be classified into three groups: "(1) those who operate immediately upon admission of the patient to the hospital (apparently regardless of the time elapsed since onset)—the "immediate" group; (2) those who operate between the first and fifth days (where apparently elapsed time since onset is given consideration)—the "early" group; and (3) those who delay intervention for weeks or even months." It is Cave's conviction that the mortality rate in the hands of the majority of surgeons is better in the so-called "early" group than in the "immediate" group.

As a starting point in the consideration of the surgical treatment of acute cholecystitis Graham's statement is singularly apropos, viz., that "the danger of operation in acute cholecystitis cannot be demonstrated in a hospital that usually practices delay, for only the bad cases will receive early operation. Conversely, a hospital that believes in early operation cannot speak with authority about the dangers of delay."

From a bacteriologic and surgical viewpoint, the findings of Edmund Andrews are of importance in this connection: (1) in many cases it is not possible to obtain posi-

tive cultures in what appears to be a very acute inflammation of the gall-bladder; (2) many cases which seem to show empyema have sterile cultures; (3) in many cases there is a stone in the cystic duct or in the ampulla, apparently slowing the blood flow from the gall-bladder.

An acute bacterial cholecystitis may not be the cause, but rather edema and obstruction of the blood supply. If these are allowed to quiet down, acute bacterial infection will develop. This is the explanation of pericholecystitis and abscess developing in the gall-bladder, producing technical difficulties in its later removal.

Burggeman drew a clear analogy when he declared that acute cholecystitis may be compared to acute salpingitis in that it rarely kills if treated conservatively. The comparison between acute cholecystitis and acute appendicitis is not in consonance with the clinical facts.

H. F. Graham, in a series of 197 consecutive cases, operated upon twenty within forty-eight hours of the onset of the acute symptoms, with one death (pancreatitis), a mortality of 5 per cent. This is, of course, a small series. In the remaining 150 cases operated upon after the forty-eight hour interval, the mortality was 6.2 per cent.

Pratt, quoted by Graham and Waters, records twenty-three cholecystectomies done within twenty-four hours of hospital entrance, without a death. The time of acute illness prior to hospital entrance and operation is not stated. In a series of forty-five cases there were no deaths when operation was done within forty-eight hours after onset of the disease.

\* From the Surgical Division of the Los Angeles County Hospital and the Surgical Department of the College of Medical Evangelists, Los Angeles.

Smith reports in a series of 1,053 cases:

	Mortality
Acute, 107 cases, 10 deaths, (operated upon at once).....	9.3
Subsided, (three or four days without fever before operation), 94 cases, 5 deaths, (operation from forty-eight hours to seven days after onset).....	5.3
Chronic, 754 cases, 24 deaths.....	3.3
Duct stones, 98 cases, 32 deaths...	33.0
Total number of cases 1053, 71 deaths.....	6.7

Five of the cases of the acute series (5 per cent) were perforated, all in the first three days after onset of the illness; eight were gangrenous; eleven empyemas were found; and eleven had abscesses located outside the gall-bladder. In several patients more than one of these complications was present. In the preceding thirty-three patients (one-third of the acute group) there occurred five deaths, one-half of the total. Thus since all fulminating cases (the thirty-three complicated cases) were included in the mortality statistics of the acute group these figures are not entirely accurate. If one deducts the thirty-three complicated cases from the 107 cases listed, there remain seventy-four strictly acute cholecystitis cases in which there were five deaths, 6.5 per cent mortality.

Smith, despite the trend toward early surgery, and certain contrary opinions, believes that ectomy in acute cholecystitis is a definitely more difficult technical procedure and states that in such cases it may be necessary to remove the gall-bladder at the ampulla rather than at the duct, as a matter of safety. Two of the cases in his series were reoperated for stones present in the remnant of the gall-bladder. Smith in a recent reversal of opinion, now believes that surgery in acute cholecystitis is unwise unless the evidence points to free perforation, in which instance immediate operation should be done.

Graham compiled a list of 153 cases of acute cholecystitis from the wards of the Toronto General Hospital for the period from July, 1, 1926 to January 1, 1934. Of these 153 cases, twenty-four refused sur-

gery and in sixty-one surgery was not advised for various reasons. Thus of sixty-eight operated cases six were operated upon at once with one death, 16 per cent mortality. In sixty-two cases delayed surgery was done, with three deaths, 4.8 per cent mortality. Four deaths occurred in the sixty-eight cases, a mortality of 5.8 per cent. The average time from onset to hospital entrance was six days.

In a series of fifty-two private patients, Graham operated immediately in seven cases and delayed surgery in forty-five. There were four fatal cases in the series, a mortality of 7.7 per cent. In the delayed surgery group of forty-five, there were eleven perforations; all of these patients survived. These cases were seen earlier after onset than those of the series of Toronto General Hospital.

Pennoyer studied 300 consecutive cases of clinically acute cholecystitis, at the Roosevelt Hospital, New York City, the cases dating back to 1918. The routine treatment had been to delay surgery in such cases until the acute symptoms subsided, operation being done only if urgent complications indicated such intervention. During more recent years, early surgery has been advocated, the reason for the change being that the danger of complication was considered greater than the danger of operative interference. Operation is now done within five days of onset unless there is definite improvement. Cholecystostomy rather than cholecystectomy is done, on the basis of safety.

In this series, the charts of 1,474 patients with gall-bladder disease were studied. The 300 cases of acute cholecystitis presented here represent a careful selection including those in which the advocates of early operation have presented evidence of justified intervention.

There were thirty deaths in the entire series, a mortality of 10 per cent. In these fatal cases, the average time of acute illness prior to hospital entrance was four days; they were observed for two and one-third days prior to operation. Thus a total of

six and one-third days represents the average time from onset to operation. Of these thirty deaths, twenty-one actually died as a result of operative procedure, a 7 per cent mortality. Fifteen deaths occurred in a series of fifty-nine cases (20 per cent of the entire series of 300), in which emergency operation was done within twelve hours of hospital entrance. In this series of fifty-nine, there were thirty-two cases, 54 per cent, incorrectly diagnosed. Thus, the fifteen deaths, operated at once as emergencies, represent a mortality of 25 per cent.

The remaining 241 patients had been acutely ill for four days prior to hospital entrance. Of these, thirty-three, after an average delay of five days, were found not subsiding or actually becoming worse. They were therefore operated upon in the presence of acute symptoms, seven deaths ensuing, a mortality of 20 per cent.

In the remaining 208 cases the symptoms subsided after an average of eight days. Thus the total time from onset to operation in these 208 cases was at least twelve days. There were five deaths in this group, a mortality rate of 2.5 per cent.

In the entire group of 241 cases there were twelve deaths, a mortality of 5 per cent.

Of the 300 cases, 20 per cent showed some gangrene of the gall-bladder wall and thirty cases showed definite rupture with resultant local peritonitis.

Cutler, in the discussion of Pennoyer's paper, insisted that only cases seen within a few hours of the onset of the attack, not two to five days after onset, should be operated upon at once. Whipple is of the same opinion. Leidberg believes that moderately severe cases of acute cholecystitis should be operated upon in two or three days, unless specific contraindications are present.

Branch and Zollinger (235 cases) performed immediate surgery in thirty-four cases, the mortality being 20.3 per cent. In 195 cases they waited an average of 4.7 days before surgery; operative mortality was reduced to 8.7 per cent.

Heuer, in a summary of 1,066 cases of acute cholecystitis subject to surgery, found a general mortality of 8 per cent and an individual mortality varying between 4.7 per cent to 22.5 per cent. The report of Judd and Phillips, concerning 508 cases of acute cholecystitis, showed a mortality percentage of 4.7. There were sixty-eight cases of perforation or gangrene, 13 per cent. Cave comments that only fourteen of these 508 patients had emergency operations. Also to be noted is the fact that of the sixty-eight cases having gangrene or perforation, sixty-one had the lesion walled off into a localized abscess. Cave has the definite conviction that the acutely inflamed gall-bladder rarely perforates into the free abdominal cavity, causing a diffuse peritonitis, but that the percentage of localized abscess following perforation is quite large.

Eliason and McLaughlin report nine perforations in a series of 500 consecutive hospital admissions for biliary disease, a percentage of 1.8. All had localized abscess, six being admitted as emergency cases. Inclusive of their own 500 cases, they record a summary of 7,316 cases; ninety-six instances of perforation occurred, 0.77 per cent. Perforation in the cases of the different surgeons of this series ranged from 0.9 to 2.5 per cent, mortality from 11 per cent (Eliason and McLaughlin) to 44 per cent.

Touroff found that 20 per cent of seventy-five cases of acute cholecystitis, in the presence of minimal or absent clinical manifestations, had progressive gall-bladder lesions. The remaining 80 per cent (sixty cases) had lesions that were subsiding or capable of subsidence. Touroff believes that if subsidence does not occur promptly and proceed regularly, early operation is indicated. In cases with subsided clinical manifestations, early operation, rather than later in the "interval" is indicated.

Shoemaker reviewed 274 operations upon the biliary tract, done by staff surgeons of the Los Angeles County Hospital from 1929 to 1931. These patients were selected from 1,186 admitted to the hospital with a diagnosis of acute or chronic cholecystitis. Of

the number of patients admitted, approximately 25 per cent were operated upon. Of these, thirty-seven died, a mortality of 13.5 per cent. Discarding the six malignancies in the series, the mortality becomes 11.3 per cent. There were two cases of acute ulcerative cholecystitis, one abscess of the liver, two gangrenous gall-bladders and four empyemas in this series.

In this survey covering all biliary cases admitted to the Los Angeles County Hospital for the five-year period, 1933-1938, we have been particularly interested in attempting to determine how much influence, if any, the elapsed time from the onset of an acute cholecystitis to operation is related to complications and mortality, the criterion to be the pathologic diagnosis rather than the surgeon's operative report, in all cases where cholecystectomy was done. In those instances where cholecystostomy was done, the surgeon's operative report was used, unless a portion of the gall-bladder had been excised and used for pathologic examination.

Questionable cases in the original list have been discarded whenever there was insufficient data. A total of 131 cases were thus excluded. These would probably have belonged in Group 1 or 2. Likewise all cases of primary pancreatic disease and all malignancies of the biliary tract (sixty-six) have been excluded. It has been impossible to tabulate the cystic duct stone cases separately because of lack of data. They are therefore included in the general tables. We are of the opinion that the importance of the cystic duct stone cases, as related to vicious complications and resultant increased mortality, has not been sufficiently stressed.

The universal policy of this hospital has been to defer surgery until the acute attack has subsided, subject to the indications for emergency operations at the discretion and judgment of the attending surgeons. It is uncommon for the acute case to enter the hospital within forty-eight hours of the onset. The patient has been ill usually from two to seven days before hospital entrance.

The suggestion of some observers that operation be done in the first forty-eight hours is limited in its applicability in this hospital.

There were 955 patients admitted with a diagnosis of biliary disease in the period 1933-1938. This includes all questionable biliary and malignant cases, which were excluded from our final tables. In the entire group, there were 704 surgical interventions.

Acute cholecystitis was diagnosed in 251 patients. Six cases are excluded because of insufficient data, leaving 245. None of this group was operated upon; either the patient refused surgical intervention or the surgeon objected, usually on the basis of other additional and advanced pathology, especially cardiorenal disease.

There were fifteen deaths in this non-operative group, a mortality of 6 per cent. Nine autopsies were done, and in all but two instances, the cause of death was other than acute cholecystitis or its complications. However, all autopsies showed the presence of cholecystitis.

Since 230 of these 245 unoperated patients apparently recovered and were dismissed from the hospital in from five to fourteen days, there is presumptive evidence that the incidence of perforation, gangrene and abscess may not be so high as some observers report.

The operative cases have been tabulated in three groups: Group 1 represents all cases operated upon within forty-eight hours of the onset of the illness. Group 2 includes those cases operated upon from the third to the sixth day inclusive after onset, and Group 3 those cases operated upon after the sixth day. All questionable cases (197) have been excluded.

*Group 1. Operation done within forty-eight hours of onset.* There were sixteen cases in this group, eight cholecystectomies and eight cholecystostomies, with three deaths, a mortality of 19 per cent.

There were five cholecystectomies in females, no deaths; three in males with one death: the mortality thus being 12.5 per

cent. Pathologic diagnoses were: two subacute, one marked subacute, one empyema, one gangrene and three chronic cholecystitis.

TABLE I  
GROUP 1  
(Operated upon within 48 hours of onset)

Sex	Type of Operation	No.	Deaths	Acute	Subacute	Chronic	Gangrene	Empyema	Hydrops
F	ect.	5	0	0	1	2	1	1	
M	ect.	3	1	0	2	1	0	0	
F	ost.	4	1	..	..	..	..	..	1
M	ost.	4	1	..	..	..	..	1	

Total, 16 cases, 3 deaths, mortality, 19 per cent  
8 ectomies, 1 death, mortality, 12.5 per cent  
8 ostomies, 2 deaths, mortality, 25 per cent

The eight cholecystostomies were evenly divided as to sex. There were two deaths, a male and a female, giving a mortality of 25 per cent. One hydrops and one empyema were included.

*Group 2. Operated upon from forty-eight hours to the seventh day after onset.* There were sixty-four cases in this group, with

TABLE II  
GROUP 2  
(Operated upon from 48 hours to the 7th day after onset)

Sex	Type of Operation	No.	Deaths	Acute	Subacute	Chronic	Ulcerative	Gangrene	Empyema	Hydrops
F	ect.	36	2	4	7	19	4	2	0	0
M	ect.	12	2	3	2	5	1	0	0	1
F	ost.	11	0	..	1	..	..	1	1	
M	ost.	5	1	..	..	..	..	1	1	

(Ulcerative, 1 acute, 1 recent acute, 1 subacute, 2 chronic)

Total, 64 cases, 5 deaths, mortality, 7.8 per cent  
48 ectomies, 4 deaths, mortality, 8.3 per cent  
16 ostomies, 1 death, mortality, 6.25 per cent

five deaths, a mortality of 8 per cent. Forty-eight cholecystectomies were done, with four deaths, a mortality of 8.3 per cent. There were thirty-six in females (2

deaths), twelve in males (two deaths). The pathologic diagnosis were: seven acute, nine subacute, five ulcerative, two gangrenous, one hydrops and twenty-four chronic. The five ulcerative cases were further classified as: one recent acute, one subacute, one acute and two chronic.

Sixteen cholecystostomies were done with one death, a mortality of 6.2 per cent. In eleven females there were no deaths. The pathology was given as one subacute, one gangrene and one empyema. In the five males there was one death.

*Group 3. Operated upon after the sixth day since onset.* The greater portion of this

TABLE III  
GROUP 3  
(Operated upon after the 6th day after onset)

Sex	Type of Operation	No.	Deaths	A	S-A	Chr.	Pur.	Ulc.	Perf.	Gang.	Emp.	Hyd.	Chol.	No report
F	ect.	311	13	8	58	208	4	21	0	0	0	1	1	10
M	ect.	79	7	3	18	45	0	7	0	1	1	0	0	4
F	ost.	27	1	..	..	..	..	..	..	..	3			
M	ost.	10	2	..	..	1	..	2	1	3				

(Purulent, 1 recent acute, 2 subacute, 1 chronic)

(Ulcerative, 4 acute, 1 recent acute, 8 subacute, 15 chronic)

Total, 427 cases, 23 deaths, mortality, 5.4 per cent  
300 ectomies, 20 deaths, mortality, 5.1 per cent  
37 ostomies, 3 deaths, mortality, 8.1 per cent

group was operated on from the fourteenth to the twenty-first day after onset, the majority on the fourteenth day. Cases of perforation, gangrene, empyema, acute ulcerative and purulent were operated upon between the seventh and fourteenth days after onset. (Table III.)

TABLE IV  
LOS ANGELES GENERAL HOSPITAL  
1933-1938

	Per Cent Mortality
704 Surgical interventions.....	13.35
638 Biliary surgery solely.....	8.77
507 Corrected list, biliary surgery	
Group 1.....	19.0
Group 2.....	7.8
Group 3.....	5.4

This group comprises 427 cases, with twenty-three deaths, a mortality of 5.4 per



cent. There were 390 cholecystectomies with twenty deaths, a mortality of 5.1 per cent. In this group 311 were females, including thirteen deaths. The pathologic diagnoses in these 311 cases included: eight acute, fifty-eight subacute, 208 chronic, one cholesterosis, one gangrene, one hydrops, four purulent, and twenty-one ulcerative. The ulcerative cases were further classified as: acute ulcerative three, subacute seven and chronic eleven. The purulent were also further classified as acute one, subacute two and chronic one. No report was given in ten instances.

There were seventy-nine cholecystectomies in males, with seven deaths. Three were acute, eighteen subacute, forty-five chronic, one empyema, one gangrene and seven ulcerative; the latter classified as: acute one, subacute one, recent acute one, and four chronic. No report was given in four cases.

Thirty-seven cholecystostomies were done, twenty-seven in females and ten in males, with three deaths, a mortality of 8.1 per cent. There was one death in a female. Three empyemas were included. In the ten males two deaths occurred. One gangrene, two perforations, three empyemas and three chronic cholecystitis were present.

#### SUMMARY

We are in accord with Smith in the belief that operation within forty-eight hours of onset carries too high a mortality to warrant much consideration, especially in the wards of a public charitable hospital whose patients are not infrequently poor surgical risks. Furthermore, these patients often do not come to the hospital within forty-eight hours of the acute onset. Our opportunities have been limited as regards statistics for this group. Our entire Group 1 series has little positive value since it is too small in numbers.

We are inclined to the view of Cutler and Whipple that any early operation,

preferably cholecystectomy, should be done within six to twelve hours of onset. So far as we have been able to determine, apparently the peak of the disease is reached in from one to four days.

In Group 2, after forty-eight hours, seven acute, ten subacute, five ulcerative, four gangrenous, two empyemas and one hydrops were present; in other words, considerable acute pathology remained. The chronic cases, almost a third, showed subsidence of the pathology. Nevertheless the mortality for this group had dropped by 60 per cent, from the 19 per cent of Group 1 to 7.8 in Group 2.

In Group 3, in which operation occurred after six days (most of them about the fourteenth day), we still find evidence of acute gall-bladder pathology. There was evidence of an active pathology in 130 cases out of 427 supposedly subsided cases. In all of these we waited, and in the majority of instances they showed minimal clinical manifestations when operated upon. Yet acute lesions were present in 31 per cent of cases. The mortality, however, dropped from 19 per cent in Group 1 and 7.8 per cent in Group 2 to 5.4 per cent in Group 3.

There were nine deaths in Group 3 due to accidental injuries of ducts and blood vessels. These deaths represented almost 40 per cent of the total mortality of this group; if these nine deaths were eliminated the mortality would be 3.5 per cent.

#### COMMENT

The very frequent occurrence of acute pathology in Groups 2 and 3 does much to influence our belief that no absolute time can be set as to the opportune moment to operate.

We are, however, firmly convinced of the verity of Touroff's observations, that advanced pathology may be present with minimal clinical manifestations and that each case should be conducted on a knowledge of Touroff's pertinent facts and be sharply individualized.

We are of the opinion that, except for those cases of perforation and gangrene which may apparently occur at any and all times, the mortality percentage will probably be lowest when operation is done about fourteen days after onset.

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NON-LITHOGENOUS cholecystitis occurs in 10 per cent of cases. As has been previously indicated, the infection is of a haematogenous origin, and is caused by a particular strain of streptococcus which exhibits a predilection for the wall of the gall-bladder.

From—"Surgery of the Alimentary Tract" by Devine (Williams & Wilkins Company).

# MECKEL'S DIVERTICULUM\*

WILLIAM W. NOEL, M.D., F.A.C.S.

DETROIT, MICHIGAN

**T**WENTY-FIVE Meckel's diverticula have been observed and described at operations in the Henry Ford Hospital during the past thirteen years. They present such a variety of findings that their study should be of interest.

Meckel's diverticulum is described as an occasional sacculatation or cecal appendage of the ileum, derived from an unobliterated vitelline duct. It is therefore a congenital anomaly due to a defect in the closure of the omphalomesenteric duct. It is a rather common anomaly; various reports of autopsy findings place its incidence at from 1.5 to 2.5 per cent. The twenty-five cases here recorded were found among approximately 12,000 intra-abdominal operations. It was thus observed in only 0.21 per cent of these patients and must have occurred in many more. Until recently it has not been searched for, unless the symptoms and findings were not explained by other pathologic processes.

Age seems to have played very little part in the discovery of these diverticula. (Table I.) Seventeen of the twenty-five, or 69 per

TABLE I

Ages	Number
1-10	4
11-20	1
21-30	5
31-40	5
41-50	7
51-60	2
77	1

cent, occurred between the ages of 20 to 50 years. Extremes of life were present in a baby of fourteen weeks and a man 77 years of age. Sex seems to play a definite rôle. There were fifteen males and ten females in this series and all were of the white race.

*Morbid Anatomy.* The diverticula vary markedly in size, shape, position and structure. The majority in this series were ap-

TABLE II

Number	Length, Cm.	Diameter, Cm.
2	2.5	
2	5.0	
3	5.0	2.5
1	5.0	4.0
1	6.0	
1	6.0	1.0
1	6.0	4.0
2	7.5	2.5
1	7.0	4
1	11.0	4
1	12.5	2
1	Small	
2	Size of distal phalanx	
4	Size of thumb	
1	Size of egg	
1	33 cm. long, size of intestine	

proximately the size of a thumb. (Table II.) The extremes varied in size from a sac less than 2.5 cm. long to one more than 33 cm. in length. The diameter was more constant, averaging 1 to 1½ inches. There were many different shapes. One was called conical, two bulbous, two tapering and one had a forked end. One had a sphincter-like mechanism at its neck.

Nine of the diverticula were described as anti-mesenteric in position, three were definitely associated with the mesentery and the exact position of the others was not mentioned. The relation to the ileocecal valve is shown in Table III. In this series they were situated from 2 inches to 3 feet from the cecum.

TABLE III  
POSITION IN RELATION TO ILEOCECAL VALVE

Number	Distance, Inches
4	36
4	24
1	20
8	18
2	10
1	2
5	Not mentioned

\* From the Department of Surgery, Henry Ford Hospital.

The majority of the diverticula lay free except for the attachment to the ileum. One was attached to the umbilicus, one had

diverticulum occurred in the mesentery just 2 inches from the cecum. It was called acquired by the operating surgeon because

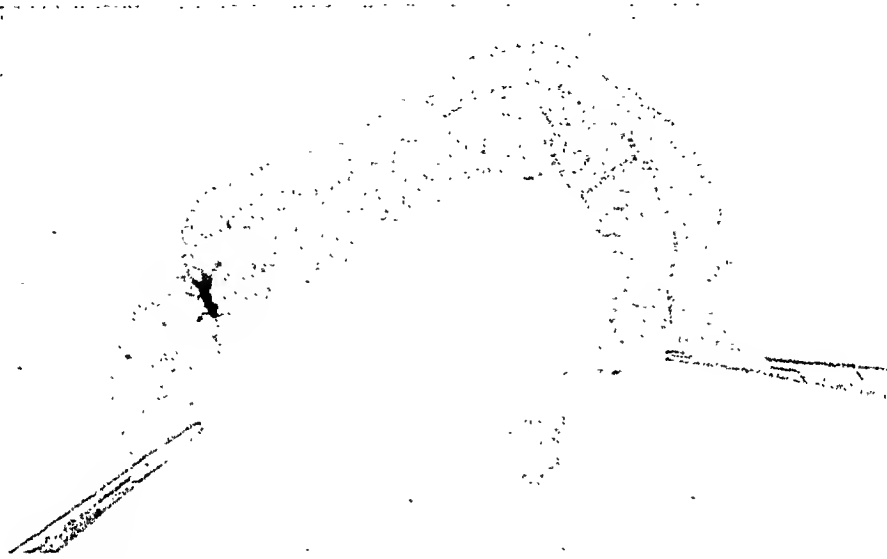


FIG. 1. Giant diverticulum. Clamp on each end of ileum. Perforation at junction of diverticulum and ileum.



FIG. 2. Ileum and diverticulum open. Note gastric mucosa.

the tip buried in the mesentery, four were bound to the mesentery by adhesions. The giant diverticulum, in close association with the ileum and its mesentery, presented the appearance of a double-barrelled portion of the intestine. The diverticulum and intestine had a common mesentery except at the distal end of the diverticulum where it possessed a separate portion. (Figs. 1 and 2.)

Three diverticula in all were closely associated with the mesentery. The smallest

of its position. It contained, however, all the usual layers of the bowel wall and is therefore classified here as congenital. The third one occurring in close relation to the mesentery proved to have a short mesentery of its own when the peritoneum over it was incised.

An acute inflammatory process was described in two cases and in three others ulceration was present. Unfortunately, amputation had to be done at the site of the ulceration in one case and enterostomy was

made at this site in another case, so the ulcers were not demonstrated pathologically. The ulcer in the last case had perfor-



FIG. 3. Diverticulum opened. Note gastric mucosa and ulcer (arrow pointing to ulcer.)

ated at the time of operation. The third diverticulum had the gastric mucosa limited to the tip with an ulcer located in the center of this. (Fig. 3.)

Intestinal obstruction was present in six cases. Adhesions binding the diverticulum to the mesentery was the cause in four

Hemorrhage from the bowel was present in three instances and from the umbilicus in a third case.

Foreign bodies in a diverticulum are rather rare. In one of these cases a bullet was present and in another many small bodies which suggested gallstones. (Fig. 4.) An analysis of one of these bodies revealed that they were composed of dried intestinal contents.

Associated anomalies occurred in three cases. The gall-bladder and cystic duct were proved to be absent at post-mortem in the man of 77. A very large tumor of the right pleural cavity, presumably a dermoid, was present in the baby with the giant diverticulum. A small cord, the remnant of the allantois was present in the patient whose diverticulum was attached to the umbilicus.

*Histopathology.* Sixteen specimens were submitted to microscopic examination. Thirteen of these were described as normal Meckel's diverticula, without inflamma-

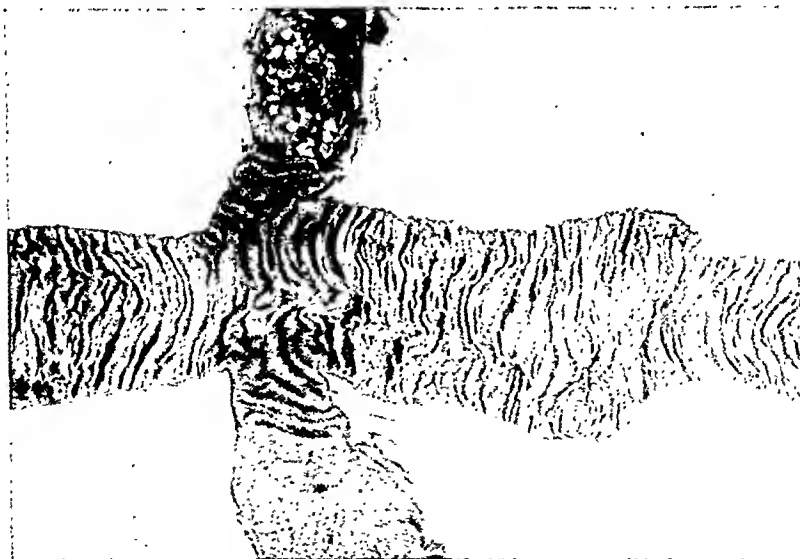


FIG. 4. Foreign bodies in a Meckel's diverticulum. The ileal mucosa in this case is acutely inflamed.

cases. In one instance the obstruction occurred about a large mesentery to the diverticulum and in the other a portion of ileum passed through a loop between the mesentery and the diverticulum, the tip of which was attached to the mesentery.

tion, two were described as acutely inflamed and one presented edema. Gastric mucosa was present in three, duodenal mucosa in two and upper jejunal mucosa in another. (Figs. 4, 5 and 6.) The aberrant mucosa was found in the recent cases and was un-

doubtedly present in some of the others. The giant diverticulum was lined throughout by gastric mucosa.

**Symptoms.** Thirteen of the patients presented no symptoms referable to the diverticulum. These patients were operated on for other conditions and the diverticulum was an incidental finding.

The other twelve patients presented symptoms directly attributable to the diverticulum or to complications resulting from its presence. The symptoms in these cases were variable depending on the pathologic involvement of the diverticulum. Six were associated with the symptoms of intestinal obstruction. There were no previous symptoms suggesting the presence of the Meckel's diverticulum. Two patients had symptoms suggestive of appendicitis and four had bleeding as a cardinal symptom. This occurred from the umbilicus in one case and from the bowel in three.

have been conjectured in at least two others, one with bleeding from the umbilicus and another in which there was the



FIG. 5. Gastric mucosa in Meckel's diverticulum.

unusual history and finding of a foreign body, presumably a bullet, occurring fre-

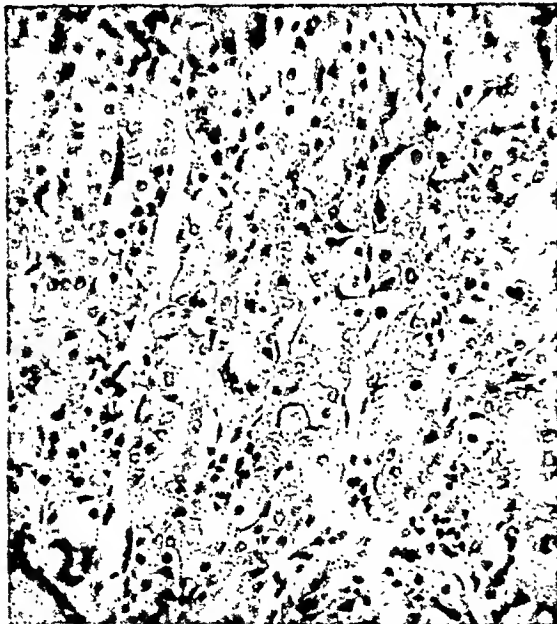


FIG. 6. High power magnification of a portion of gastric mucosa shown in Figure 4.



FIG. 7. Duodenal mucosa in a Meckel's diverticulum.

**Diagnosis.** The preoperative impression was correct in only three of the cases as described. (Table IV.) The diagnosis could

quently in a right scrotal hernia. This last patient had been shot through the abdomen some years before. The fact that the bullet was found in the hernial sac was proof that it must have been in an intestinal diverticulum or possibly in the omentum. In six patients with intestinal obstruction the diagnosis was made preoperatively in four.

TABLE IV	
Diagnosis	No.
Intestinal obstruction.....	6
Appendicitis.....	2
Meckel's diverticulitis (with bleeding).....	3
Patent urachus (with bleeding).....	1

The other two were diagnosed as appendicitis and obstruction to the cystic duct. The last patient was jaundiced, apparently due to some obstruction about the cystic duct which had been anastomosed to the duodenum some time before. The intestinal obstruction also played some part in the obstruction to the cystic duct. An operative diagnosis of Meckel's diverticulitis was made in one case where symptoms suggested appendicitis, and in another where intestinal obstruction had been considered probable. Despite the fact that the findings were those of an acute abdomen and the white blood counts were 15,000 and 12,000, respectively, two diverticula, called acute at operation, showed only mild edema in one and entirely normal structure in the other.

A rather typical history and findings made possible the correct diagnosis in one patient aged 7 years. Five weeks before admission there were abdominal cramps followed by a grossly bloody stool and a feeling of faintness. Anorexia persisted until the day before admission, when there was nausea associated with abdominal pain. The findings of right lower quadrant tenderness, spasm and rebound tenderness, associated with a white blood count of 9,200 and 81 per cent polymorphonuclear cells suggested the diagnosis of Meckel's diverticulitis. In a patient with frequent hemorrhages from the bowel and abdominal patterns suggesting some degree of obstruction, and in another patient who reported two episodes of profuse intestinal bleeding associated with nausea, there was even less difficulty in diagnosis.

*Treatment.* The treatment is always surgical. The pathologic process resulting as a complication of the diverticulum must be given first attention, but the diverticulum should usually be removed.

The diverticula here reported were seen by seven different surgeons. Treatment was of five different types. (Table v.) The diverticulum was inverted in a case of intestinal obstruction, presenting a greatly dilated bowel and a dilated, thin-walled, wide-

TABLE V  
METHOD OF TREATMENT OF THE DIVERTICULUM

Excised in the manner of an appendix.	13
Inverted with enterostomy.....	1
Resected along with portion of ileum.	5
Exteriorized with portion of bowel...	1
Left undisturbed.....	5

mouthed diverticulum, obstructed about a large mesentery to the diverticulum. The mesentery with its large vessels was divided and a simple inversion carried out, the bowel being brought together transversely with interrupted sutures of silk. It was felt that the diverticulum would certainly slough. A simple enterostomy, with a mushroom catheter, was made about 18 inches above this. The catheter was held in the bowel with a purse-string suture of silk, the free end being drawn through a stab wound in the abdominal wall, thus approximating the bowel to the peritoneum. The enterostomy closed promptly after removal of the tube on the fourteenth postoperative day.

The diverticula were small-necked sacs in thirteen cases; these were treated as we would treat an appendix. A purse-string suture was placed about the base of the diverticulum and sterile gauze applied around it. The peritoneum was incised about 0.5 cm. above the purse-string, this area was crushed with a small clamp, and the neck ligated with catgut. A Halsted clamp was placed distal to the ligature and the diverticulum divided. The stump was carbolized and inverted through the purse-string suture, which was drawn taught. An improvement in technique at this point is to place several interrupted Lambert sutures to strengthen the inversion, before the purse-string suture is tied, in this way avoiding the protrusion of the stump that sometimes occurs when the purse-string is inadvertently broken. This treatment of the diverticulum is the method of choice in most instances.

The bowel was resected in five cases. This was deemed to be necessary in three cases of intestinal obstruction, in one case of terminal ileitis and in one case in which the bowel and diverticulum possessed a mesentery in common. The resection usually

consisted in removing a short piece of ileum on each side of the sac, with a lateral anastomosis completing the operation.

The diverticulum was exteriorized along with the gangrenous bowel in the case of the strangulated hernia. It had nothing to do with the strangulation.

**Mortality.** Two patients in this series died. The 77 year old patient died three days after operation. A woman of 56 died from intestinal obstruction associated with a strangulated hernia. Only twenty of the twenty-five cases had any form of treatment directed to the diverticulum so this would give a mortality rate of 10.0 per cent. The prognosis is good for complete recovery after the diverticulum is removed.

CASE REPORTS

- Asymptomatic Group.* 1. G. G. Male, white, 46 years old. Bleeding duodenal ulcer. Posterior gastroenterostomy, excision of diverticulum. Pathology—Meekel's diverticulum. Recovery.
2. M. H. Female, white, 26 years old. Chronic appendicitis. Appendectomy, excision of Meckel's diverticulum. Pathology—acute Meckel's diverticulitis. Recovery.
3. E. B. Female, white, 28 years old. Salpingitis. Salpingectomy, appendectomy, excision of Meckel's diverticulum. Pathology—Meckel's diverticulum. Recovery.
4. S. V. Male, white, 43 years old. Terminal ileitis with abscess. Resection of terminal ileum and diverticulum, appendectomy. Pathology—Meckel's diverticulum, duodenal mucosa. Recovery.

RESULTS AND FOLLOW-UP

	Treatment	Last seen	Result
Asymptomatic group associated with:			
Bleeding duodenal ulcer.....	Resected	8 years	Well. (Later resection ulcer.)
Chronic appendicitis.....	Resected	3 years	Well
Salpingitis.....	Resected	10 years	Primary anemia
Hernia.....	Resected	1 month	Well
Strangulated hernia.....	Exteriorized	24 hours	Expired
Terminal ileitis.....	Resected ileum	1 year	Well
Recurrent appendicitis.....	Resected	2 months	Well
Salpingitis.....	Resected	1 month	Well
Symptomatic group associated with:			
Intestinal obstruction.....	Resection ileum	13 months	Well
Intestinal obstruction.....	Resected	3 days	Expired
Intestinal obstruction.....	Resected	5 years	Well
Intestinal obstruction.....	Inverted	24 months	Well
Intestinal obstruction.....	Resection ileum	6 months	Well
Intestinal obstruction.....	Resection ileum	5 months	Well
Associated with hemorrhage from:			
Umbilicus.....	Resected	1 month	Well
Bowel.....	Resected	7 months	Well
Bowel.....	Resection ileum	18 months	Well
Bowel.....	Resected	1 month	Well
Acute diverticulitis:			
First.....	Resected	1 month	Well
Second.....	Resected	2 months	Well

The follow-up has been inadequate, but it is to be noted that none of the patients has returned for treatment for a cause in any way associated with the diverticulum. This is especially noteworthy since in five cases the diverticulum was not disturbed.

5. M. C. Female, white, 30 years old. Recurrent appendicitis. Appendectomy, excision of Meckel's diverticulum. Pathology—Meckel's diverticulum. Recovery.
6. J. W. Male, white, 35 years old. Gunshot wound in abdomen, 1929. Right inguinal hernia with bullet palpable in sac at times. Hernioplasty, excision of Meckel's divertic-



ulum, appendectomy. Pathology—Meckel's diverticulum. Recovery.

7. E. S. Female, white, 56 years old. Strangulated inguinal hernia, right, with Meckel's diverticulum in the sac. Exteriorization of the bowel and diverticulum. Expired in twenty-four hours.

8. I. B. Female, white, 38 years old. Salpingitis. Release of adhesions, excision of corpus luteum cyst, excision of Meckel's diverticulum, appendectomy. Pathology—Meckel's diverticulum. Recovery.

*Intestinal Obstruction Group.* 9. B. E. Female, white, 38 years old. Generalized pain, nausea and vomiting for thirty-six hours. Previous appendectomy and cholecystectomy. Acutely ill, distended R.L.Q. tenderness and spasm. X-ray-dilated coils. W.B.C. 10,800; 83 per cent polys. Intestinal obstruction about a swollen, adherent Meckel's diverticulum. Resection of 10 inches of ileum with diverticulum. Pathology—Meckel's diverticulitis with multiple concretions. Recovery.

10. G. P. Male, white, 77 years old. Generalized pain, nausea and vomiting for two days. Ill, distended, R.L.Q. tenderness and spasm. W.B.C. 9,500, 72 per cent polys. Diagnosis—intestinal obstruction about a Meckel's diverticulum involved in adhesions. Release of obstruction, excision of diverticulum. Pathology—Meckel's diverticulum. Expired in three days. Autopsy, absent gall-bladder and cystic duct.

11. A. K. Female, white, 46 years old. Para-umbilical pain, nausea, and vomiting of four days' duration. Moderately ill, distended, generalized tenderness. W.B.C. 7,700. Diagnosis—intestinal obstruction about mesentery of Meckel's diverticulum. Release of obstruction, division of mesentery, inversion of diverticulum and enterostomy. No specimen. Recovery.

12. H. N. Male, white, 21 years old. Generalized pain, nausea and vomiting of two days' duration. Ill, generalized and R.L.Q. tenderness and spasm. W.B.C. 8,900, 78 per cent polys. Impression—probably appendicitis. Diagnosis—intestinal obstruction, loop of bowel between diverticulum and mesentery of ileum to which it was bound. Release of obstruction, excision of Meckel's diverticulum. Pathology—Meckel's diverticulum. Recovery.

13. R. S. Male, white, 47 years old. R.U.Q. pain, nausea and vomiting, jaundice, recurrent. Ill, R.U.Q. tenderness. Impression—obstruc-

tion to a transplanted cystic duct. Diagnosis—partial intestinal obstruction about a Meckel's diverticulum bound down by adhesions. Resection of 4 inches of ileum with the diverticulum. Pathology—Meckel's diverticulum with sphincter-like neck, duodenal mucosa. Recovery.

14. J. T. Male, white, 37 years old. Epigastric pain, nausea and vomiting of three days' duration. Not acutely ill, epigastric tenderness. W.B.C. 9,900, 72 per cent polys. X-ray suggested terminal ileitis. Impression of terminal ileitis with obstruction. Diagnosis—intestinal obstruction about a Meckel's diverticulum involved in adhesions. Resection of portion of ileum with Meckel's diverticulum. Pathology—Meckel's diverticulum, gastric mucosa. Recovery.

*Acute Diverticulitis Group.* 15. M. B. Male, white, 15 years old. R.L.Q. pain, nausea and vomiting of six hours' duration. Ill, R.L.Q. tenderness and spasm. W.B.C. 14,950, 93 per cent polys. Impression—acute appendicitis. Diagnosis—Meckel's diverticulitis. Excision. Pathology—edema of Meckel's diverticulum. Recovery.

16. C. G. Male, white, 22 years old. Generalized pain, nausea and vomiting of five days' duration. Ill, right sided tenderness and spasm. W.B.C. 12,000, 82 per cent polys. Impression—intestinal obstruction. Diagnosis—Meckel's diverticulitis. Excision of Meckel's diverticulum and appendectomy. Pathology—Meckel's diverticulum. Recovery.

*Group with Bleeding.* 17. E. S. Male, white, eight months old. Fistula at umbilicus since birth. Profuse bleeding from umbilicus at six and seven months. Impression—patent urachus. Diagnosis—persistent omphalomesenteric duct, remains of urachus. Excision of Meckel's diverticulum and fibrous cord. Pathology—Meckel's diverticulum. Recovery.

18. J. K. Female, white, 7 years old. R.L.Q. pain and nausea of two days' duration. Abdominal cramps associated with rectal bleeding five weeks before. Ill, R.L.Q. tenderness and spasm. W.B.C. 9,200, 81 per cent polys. Impression—Meckel's diverticulitis. Diagnosis—Meckel's diverticulitis with ulceration. Excision. Pathology—Meckel's diverticulum with upper jejunal mucosa. Recovery.

19. L. McR. Male, white, fourteen weeks old. Hemorrhage from the bowel at eight weeks and at fourteen weeks. Abdominal patterns. W.B.C. 22,000, 52 per cent polys, R.B.C.

1,800,000. Impression—probable Meckel's diverticulitis. Diagnosis—giant Meckel's diverticulitis with ulceration and perforation. Enterostomy and later resection portion of ileum and diverticulum. Pathology—Meckel's diverticulum with gastric mucosa. Associated finding probable dermoid cyst of right pleural cavity.

20. G. T. Male, white, 9 $\frac{1}{2}$  years old. Hemorrhage from the bowel at 8 $\frac{1}{2}$  years. Some nausea followed by bloody stool prior to admission. Abdomen essentially normal. R.B.C. 2,650,000, Hgb. 7 Gm. Impression—ulcer of Meckel's diverticulum. Diagnosis—Meckel's diverticulum—gastric mucosa with ulceration. Excision of Meckel's—appendectomy. Pathology—Meckel's diverticulum with gastric mucosa. Recovery.

21-25.\* The diverticula were left undisturbed in five cases. Cholecystectomy was performed in two of these cases, appendectomy in one, a resection of the rectum in the fourth, and release of adhesions in the fifth.

#### DISCUSSION

Twenty-five patients with Meckel's diverticula have been presented. There was one death in six cases with intestinal obstruction, excluding the case with the strangulated hernia in which the diverticulum played no part. This gives a mortality rate of 16.6 per cent for this group. Halsted<sup>1</sup> reports sixty-nine cases of intestinal obstruction associated with Meckel's diverticulum; fifty-seven of these came to operation with a resultant death rate of 59.1 per cent. He gives some interesting figures on the conditions found. Forty-eight diverticula were attached to some intraperitoneal structure; twenty-three to the

mesentery, fifteen to the umbilicus, three to the small intestine, one to the mesocolon, one to the mesorectum, one to the omentum and one to the appendix. Fifteen were quite free and six were not described.

The anatomic types most frequently seen are described by Thompson<sup>2</sup> and those of this series are compared with his figures.

1. Located on antimesenteric side, with closed distal end—82.5 per cent. This series 80.0 per cent (probably).

2. Partially obliterated with fibrous cord to the umbilicus—10 per cent. This series none.

3. Umbilical fistula—6 per cent. This series 4.0 per cent.

4. Giant diverticula—5 per cent. This series 4.0 per cent.

5. Umbilical polyp—0.5 per cent. This series none.

6. Simple intramesenteric—0.5 per cent. This series 4.0 per cent.

Other malformations have frequently been found accompanying a Meckel's diverticulum. Christie<sup>3</sup> in sixty-three cases found twenty-one associated anomalies. These appeared to be most common in the brain and cord, heart, urinary tract, spleen and stomach, in the order named. Moll<sup>4</sup> reports a retention cyst in the left pleural cavity in a patient presenting a giant Meckel's diverticulum 33.5 inches long. Three anomalies in this series consisted of the tumor of the right pleural cavity, probably a dermoid, associated with the giant diverticulum, the absence of the gall-bladder and cystic duct in the oldest patient and the small remnant of the urachus.

Hemorrhage from a Meckel's diverticulum is usually or possibly always associated with ulcer, even though the ulcer is not always demonstrable. Achsner and Kareltz,<sup>5</sup> in thirty-three cases collected from the literature in 1930, found that all except five reported the passage of blood. The ulcer usually occurs at the junction of the diverticulum with the ileum. Brown and Pemberton<sup>6</sup> in eight cases with ulcer, noted a history of bleeding from the bowel in 100 per cent, and all these diverticula were

\* Dr. A. G. Lambert has recently had a further case in the hospital. A. T. Male, white, 38 years old. Generalized abdominal pain of two days' duration. Frequent vomiting. A similar attack one month before associated with diarrhea. Amebic dysentery in 1935. Ill, generalized abdominal tenderness and muscle spasm. Moderate distention. W.B.C. 4,400, 44 per cent polys. Impression—intestinal obstruction of small bowel. Diagnosis intestinal obstruction about mesentery of a Meckel's diverticulum, to which the omentum was densely adherent. Release of obstruction and resection of diverticulum. Pathology—Meckel's diverticulum, ileal mucosa with ulceration. Course—satisfactory.

lined with gastric mucosa. Gastric mucosa was present in only two of the four cases in this series presenting bleeding as a cardinal symptom. Upper jejunal mucosa was found in the third and normal ileal mucosa in the fourth case. One patient with typical gastric mucosa gave no history of bleeding. Hemorrhage from a Meckel's diverticulum occurs most frequently in infancy.

Various theories have been advanced to explain the presence of gastric mucosa in a Meckel's diverticulum. These are ably discussed by Goetsch,<sup>7</sup> Curd,<sup>8</sup> Edwards,<sup>9</sup> and Greenblatt.<sup>10</sup> The two chief theories, as described by Curd, are that it represents displaced fragments engrafted in the vitelline duct or, more probably, that the primitive endoderm has pluripotential powers and develops this type of mucosa. It may develop any type of digestive gland if stimulated locally, in some undetermined manner. This stimulus may be irritation, infection, lack of bile, retarded growth at different levels of the intestinal tract, etc. He found gastric mucosa in three of eighteen cases which he reported.

There is considerable speculation regarding the etiology of the giant diverticula. Edwards<sup>9</sup> presents a giant diverticulum 28.5 inches long arising in the mesentery a few inches from the ileocecal valve. Eighteen inches from the valve in the same case there was a typical Meckel's diverticulum. He feels that the giant diverticula are in no way related to a Meckel's but are in all probability true reduplications of the bowel. They represent attempts at the formation of a twin, this having come at a late stage of development, the reduplication being limited to one segment of bowel. Edwards reports many interesting reduplications of the bowel as found in the Royal College of Surgeons and St. Bartholomew's museums. Moll,<sup>4</sup> Yates,<sup>11</sup> Abt and Strauss<sup>12</sup> and Goldstein and Cragg<sup>13</sup> report giant diverticula. The giant diverticulum described by Edwards<sup>9</sup> and the one in this series both showed a mucosa made up of two parts, a superficial layer resembling intestinal mucosa and a deeper layer re-

sembling gastric mucosa. He suggests that the diverticula contain acid juice but this was not true in our case.

Foreign bodies in a Meckel's diverticulum are unique findings. Abt and Strauss<sup>12</sup> refer to multiple concretions in one of their cases and this occurred in one of this series. An analysis of the concretions, which resembled gallstones, revealed that they were made up of dried intestinal contents. A bullet was present in one case. This must have entered the bowel and then passed along it until it lodged in the diverticulum. Even more interesting is the fact that it frequently presented in the right scrotal hernia and was palpated there. Webster<sup>14</sup> reports a case of an inflamed Meckel's diverticulum in a left hernia.

There seems to be a consensus of opinion that a patient presenting an unexplained anemia associated with blood in the stools, in the presence of normal stomach and colon by proctoscopic and x-ray examination, should be strongly suspected of having an ulcer of Meckel's diverticulum.

Acute inflammation of the diverticulum was present in only two instances and edema in a third. This would indicate that inflammatory processes are of less frequent occurrence than some of the other complications involving a Meckel's diverticulum. When patients come to operation with a diagnosis of appendicitis and the findings in the appendix are insufficient to account for the picture, a search should be made for a Meckel's diverticulum. This should consist in the examination of 3 or 4 feet of the terminal ileum.

Five methods of treatment were used by the seven surgeons. The usual and simplest method was to excise the diverticulum in the same manner as an appendix. This is very satisfactory in a majority of cases. The bowel was resected only when its blood supply was interfered with or the diverticulum was so large that an anastomosis seemed of less danger than the excision.

Inversion of the diverticulum is an easy method of treatment and it seemed to be a life-saving measure in one case. The possi-

bility of the inverted mass initiating an intussusception must be kept in mind. No other satisfactory method appeared possible in the patient in which it was used. Harbin,<sup>15</sup> in thirteen cases, inverted two and resected eleven. The exteriorization of the diverticulum was carried out in the strangulated hernia since no extensive operation could be performed.

#### CONCLUSIONS

1. Twenty-five Meckel's diverticula have been observed during the process of approximately 12,000 intraperitoneal operations, an incidence of 0.21 per cent.

2. Meckel's diverticula have been observed at the extremes of life. In this series one occurred at the age of 14 weeks and another at 77 years.

3. Twelve of the twenty-five diverticula, or 48 per cent, gave rise to symptoms which indicated their removal.

4. Meckel's diverticula should be removed in all cases where this procedure does not add appreciably to the risk of the operation.

5. Meckel's diverticulum is an important factor in the production of intestinal obstruction.

6. The preoperative diagnosis of Meckel's diverticulitis is difficult unless there are complications to suggest its presence. Vague abdominal pain associated with anemia and the passage of blood per rectum, usually occurring in childhood, is suggestive of the diagnosis of ulcer of Meckel's diverticulum.

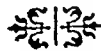
7. Excision of the diverticulum with the same technique as used with the appendix

is the usual method of choice. Resection of the bowel and inversion should be carried out only for special indications.

8. A search should always be made for a Meckel's diverticulum if the lesion at operation is insufficient to account for the preoperative symptoms and findings.

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# A TECHNIQUE FOR ANAL REPAIR

CHELSEA EATON, M.D.

Attending Proctologist, Highland and Berkeley Hospitals

OAKLAND, CALIFORNIA

THE fragility and complexity of the anorectal tissues as demonstrated by recent anatomic studies<sup>1,2</sup> leave the important inference for the surgeon that operative trauma should be minimized. And because there is a direct ratio between the degree of such trauma and the degree of "working exposure" required for the proper performance of common rectal operations, it follows that the patient's welfare will be best served when such exposure is established at the minimum which is consistent with good surgery.<sup>3</sup>

Although the use of an operative speculum (not a bivalve type) is accompanied by the minimum of traction trauma, it is of value only to the surgeon who can adapt his procedure to the space afforded by the instrument. Uncontrolled bleeding, a hindrance to any operation, is a greater obstacle when dealing with tissues within the confines of a speculum. Direct vision is obscured and guiding landmarks lost. Further surgical progress is impeded when the operative field is obstructed with hemostatic forceps.

Aside from the difficulties that arise from impaired visibility, the actual manipulative technique or instrumentation becomes a definite problem if one is to accomplish his surgical aim in a field of restricted exposure.

These difficulties, however, do not constitute valid reasons for discarding this method in favor of those that are accompanied by traction trauma. Here, technique should be reasonably adapted to anatomic topography as it is in other branches of orificial surgery. Certainly, the ultimate advantages for both patient and surgeon justify a similar adaptation in rectal surgery.

Moderate experience in dealing with anorectal tissues in situ will usually yield

to the operator many helpful ideas which facilitate this type of surgical procedure. In hemorrhoidectomy, for example, difficulties in regard to visibility and instrumentation may be prevented by consideration of the surgical anatomy in relation to the pathologic area. By instituting a progression of "surgical steps" which conforms to the anatomic arrangement of the anorectal tissues, the procedure may be simplified.

Since bleeding may be a troublesome factor, it is logical to direct the surgical approach and establish hemostasis at the highest level in the surgical field from whence bleeding emanates. This is the site of the deep branch of the inferior hemorrhoidal artery which enters the submucosal space of the canal above the profundus division of the external sphincter.<sup>4</sup> The level lies midway between two easily palpated landmarks: the intermuscular groove and the puborectalis muscle which separates the rectal ampulla from the anal canal. Hence, a preliminary transverse incision is made at this level which demarcates the underlying pathological area to be excised. (Fig. 1A.) With hemostasis established (by lightly drawing the curtain of the overlying membrane against the bleeding wall) the underlying row of infected crypts and hemorrhoidal membrane is accessible for dissection. (Fig. 1B.)

Provisions for the subsequent coverage of operative raw space are made when removing this pathologic tissue. By first bisecting the hemorrhoidal mass underlying the preliminary transverse incision, flaps are created from whose posterior surfaces the varicose vascular plexus may be excised. (Fig. 1C.) After surplus tissue is trimmed from these flaps, they may be used to cover the operative raw space. (Fig. 1D.)

Adequate drainage of this infected field may be accomplished by the manner in which the overlying cut edge of the mem-

brane is united to the subjacent tissue. (Fig. 1E and F.) Suturing this edge to the underlying sphincter in such a manner as to leave an intervening space will establish

sufficient drainage to prevent postoperative deformity and to promote smooth healing. Instrumentation is facilitated by select-

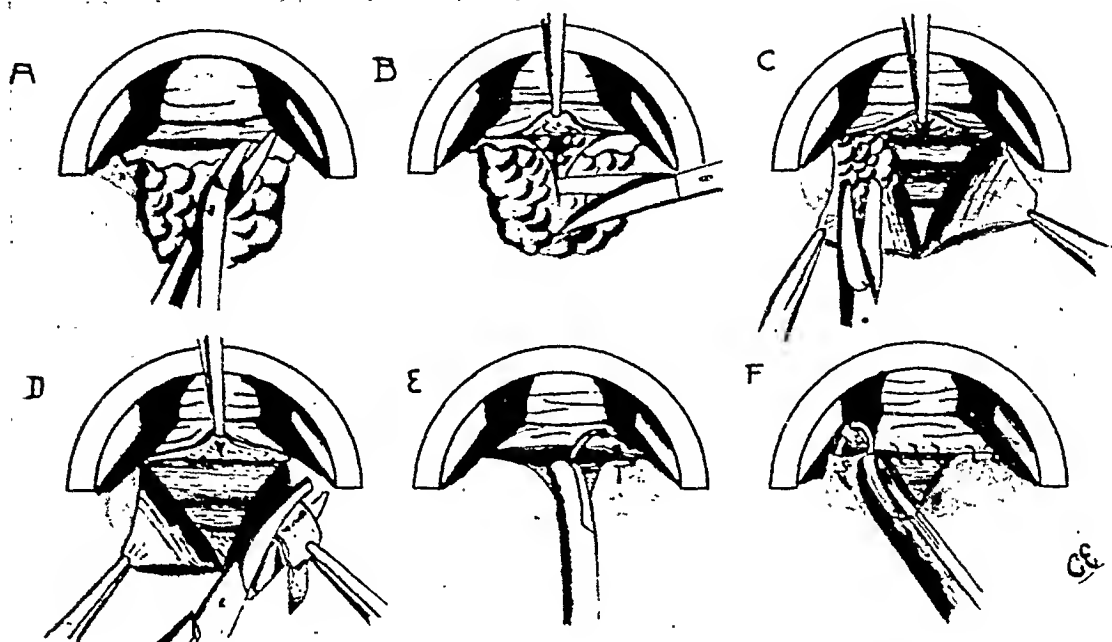


FIG. 1. A, transverse incision above the dentate line. B, bisection of hemorrhoidal mass. C, excision of hemorrhoidal varicosities. D, removal of redundant membrane. E, beginning of closure. F, half Lembert sutures with drainage defect.

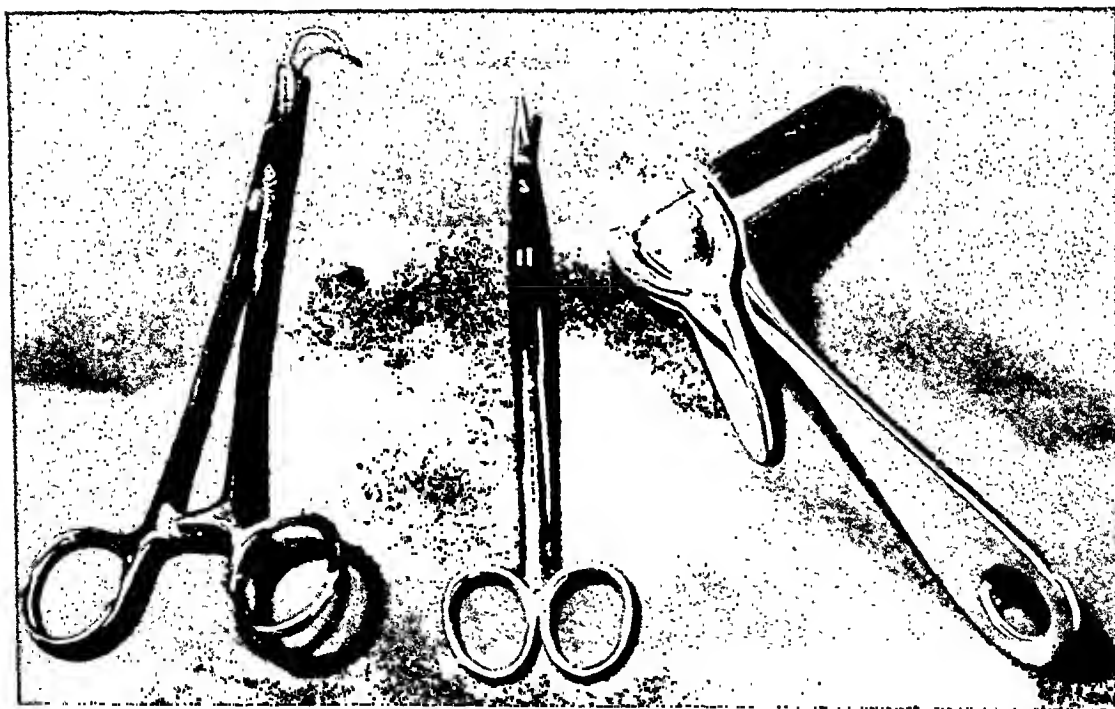


FIG. 2. Showing curved needle holder, angulated scissors, and operative speculum containing revolving obturator.

brane is united to the subjacent tissue. (Fig. 1E and F.) Suturing this edge to the underlying sphincter in such a manner as to leave an intervening space will establish

ing instruments whose size and shape conform to the restricted operative field. The preliminary transverse incision can be made most accurately with angulated

scissors. Also, a curved needle holder that grasps the needle at its tip, holding it at the proper angle, is of advantage. Finally, a nontraumatic speculum that affords 180 degree exposure has been found adequate. (Fig. 2.)

#### SUMMARY

With the conviction established that better operative results, with less pain and disability for the patient, can be obtained in rectal surgery by minimizing traction trauma, suggestions are made to facilitate

the use of a restricted field of surgical exposure.<sup>5</sup>

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VARICOSE veins of the vulva rarely require surgical treatment. When extremely large, however, they may be excised, preferably with the patient under general anesthesia and with the usual strict precaution in regard to hemostasis which this region requires.

From—"Minor Surgery" by Christopher (Saunders).

# ARTERIOSCLEROTIC GANGRENE—A MAJOR CLINICAL PROBLEM\*

LAWRENCE N. ATLAS, M.D.

CLEVELAND, OHIO

**A**RTERIOSCLEROTIC gangrene constitutes one of the most serious of clinical problems. When one considers that most of these patients come to major amputation, and that the mortality of major amputation for gangrene, as reported from various clinics, ranges from 13 to 65 per cent, the seriousness of the disease is apparent.

The higher mortality rates occur when: (1) patients present themselves for treatment in a moribund condition; (2) insufficient attention is paid to details concerned with the medical care of these patients, their preoperative preparation, and the operation itself; (3) when treatment designed to effect a local separation of the gangrenous part is employed in unsuitable cases, or when it is extended beyond the point where it is safe. The last point requires considerable elaboration because in recent years there has been an attempt in certain quarters to create the impression that arteriosclerotic gangrene is usually amenable to various forms of so-called "conservative" peripheral vascular therapy. This has proved to be unwarranted and dangerous. A little reflection on the basic pathology of the disease enables one to understand why.

Arteriosclerotic gangrene involves chiefly the toes, which receive their blood supply through end arteries. Should these vessels thrombose, there is little chance for the rapid development of an effective collateral circulation; and the ischemia often progresses to frank gangrene. Once gangrene occurs, nature makes an effort to separate and slough off the dead part. Gangrenous toes are separated by an inflammatory process involving all the forces of destruc-

tion and repair. Since the plane of separation must pass through fascia, tendon, and bone, as well as skin and subcutaneous



FIG. 1. Diabetic with advanced arteriosclerosis. No pulsation palpable in pedal arteries. Oseillometric reading lower leg—zero. Upper photograph taken on admission; lower one week later. Supracondylar amputation advised but refused. Patient expired from sepsis.

tissue, a good blood supply to the zone of demarcation is essential if separation is to take place. This is usually not present. If it is, the intense inflammatory reaction in the adjacent tissue may produce further arterial thrombosis with consequent spread of the gangrenous process. With a spread-

\* From the Peripheral Vascular Service, Surgical Division of Cleveland City Hospital, the Department of Orthopedics of Mount Sinai Hospital, and the Department of Surgery, School of Medicine, Western Reserve University.



ing gangrene, there is the danger of absorption of toxic products. Such an absorption may affect seriously an associated diabetes

slim that the life of the patient is jeopardized to attain an unusual and spectacular result.



FIG. 2. Diabetic with minimal arteriosclerosis. Good pulsation palpable in pedal arteries. Oscillometer registered good pulsation in lower leg. Gangrene of both great toes followed burns from hot water bottle. Gangrenous tissue demarcated, separated, and residual ulcers healed.

or a diseased myocardium or renal parenchyma. (Fig. 1.) Finally, there is the specter of infection. Every patient with arteriosclerotic gangrene is an excellent candidate for gas bacillus infection, tetanus, and septicemia; and because of the poor blood supply to the involved extremity, the progression of the infection may be extremely rapid and fatal.

Considered in the light of its pathology, arteriosclerotic gangrene can be looked upon as a fatal disease, and major amputation as a life saving measure.

The question arises when, if ever, is conservative treatment indicated and safe. It is very difficult to generalize. Each case presents its own particular problems. We consider it safe to attempt tentative conservative treatment designed to effect a local separation of the gangrenous part in any case of arteriosclerotic gangrene when:

1. The gangrenous process is localized to a single toe. There have, of course, been reports of conservative treatment successfully employed in instances of more extensive gangrene than this. However, the chances of successfully terminating conservative treatment in instances of more extensive arteriosclerotic gangrene are so

2. The gangrenous process is well demarcated with no tendency to spread.

3. There is no constitutional evidence of toxic absorption.

4. There is no cellulitis, osteomyelitis, or lymphangitis.

In the above type of case there is little pain, no fever, no loss of appetite or weight, no persistent tachycardia, and no retention of nitrogenous waste products. Any associated diabetes will be easily controlled. While diabetes, per se, is no contraindication to conservative treatment in this type of case, it has been my experience that failure is to be expected unless an adequate circulation is present in the uninvolved portion of the foot. (Fig. 2.) For interesting and informative statistics on this phase of the subject, the reader is referred to McKittrick.<sup>1</sup>

Our method of handling these cases conservatively is very simple. Every patient receives a prophylactic injection of gas and tetanus bacillus antitoxin on admission. We do not use any of the various types of passive vascular apparatus until complete separation of the gangrenous part has occurred. We have several times seen a rapid spread of gangrene in apparently favorable

cases follow the use of passive vascular machinery. Complete bed rest is enforced. The leg is kept at a lower level than the

healthy tissue has subsided, and not until then, the gangrenous part is gently detached from the foot. A granulating ulcer



FIG. 3. Arteriosclerosis not complicated by diabetes. No pulsation palpable in pedal arteries. Oscillometric reading lower leg—zero. Shows ulcer remaining after separation of gangrenous toe.



FIG. 4. Arteriosclerosis not complicated by diabetes. No pulsation palpable in pedal arteries. Oscillometric reading lower leg—zero. A case of infected subungual ulceration of great toe with gangrene of nail bed and adjacent tissue. Shows end result following treatment as outlined in text.

heart. Many of these patients feel better if they are allowed to sit up in bed. A cradle without lights is used to protect the foot, and the gangrenous toe is kept scrupulously clean and protected with sterile dressings saturated with azochloramid,<sup>2</sup> or a suspension of zinc peroxide in sterile distilled water.<sup>3</sup> The leg and foot are swathed in cotton to conserve body heat. Unless contraindicated, 100 c.c. of 5 per cent saline are given intravenously every other day, and whiskey is used as a vasodilating drug. My experience with enzyme-free pancreatic extract has been limited. However, in view of recent enthusiastic reports,<sup>4</sup> it deserves trial. My experience with peripheral nerve crush, periarterial sympathectomy, and lumbar sympathectomy in the treatment of arteriosclerotic gangrene has not been encouraging. When the gangrenous tissue has been converted into a loose sloughing mass, and all reaction in the adjacent

remains. (Fig. 3.) At this stage, treatment with the intermittent venous occlusion apparatus is very useful to assist in healing the residual ulcer.

At the first sign of a spread of the gangrenous process, of the onset of infection, or of toxic absorption, conservative treatment is terminated and major amputation is performed. Here, as in conservative treatment, the coöperation of an internist skilled in the handling of diabetic, cardiac and renal problems is desirable. These patients have a much better chance of surviving their operation if pains are taken preoperatively to replenish their depleted body fluids, to build up their nutrition, and to correct associated medical difficulties. The operation of choice is the well known circular amputation through the lower

third of the thigh with primary closure, using a low spinal anesthesia of no more than 50 mg. of novocaine. In the event of a cellulitis of the foot or a lymphangitis, a simple guillotine through the upper third of the leg with the stump left open is rapidly performed under nitrous oxide anesthesia. The open stump is treated with zinc peroxide using the technique described by Meleney.<sup>3</sup> Sulfanilamide, deep x-ray therapy for gas bacillus infection,<sup>5</sup> and small blood transfusions are used where indicated. At a later date, when all risk of infection of a primarily closed stump has disappeared, necessary stump revisions or reamputation at a higher level may be performed. A thigh amputation with primary closure in the presence of a cellulitis of the foot or a lymphangitis carries a grave risk of a badly infected stump. These elderly patients do not tolerate an infected amputation stump any better than they do an infected foot, and often succumb. Infected amputation stumps constitute one of the leading causes of mortality. (According to J. Ross Veal,<sup>6</sup> the danger in an infected amputation stump is that of septic pulmonary embolism. He has effected a large reduction in his mortality by the simple expedient of ligating the femoral vein just distal to the entrance of the saphenous vein at the time the amputation is performed.)

A type of gangrene occasionally seen in ischemic feet is in a class by itself. It involves the soft parts at the tip of, usually, the great toe, and is initiated by a neglected

infection starting beneath the nail. Gentle removal of the "floating" portion of the nail to allow drainage of the infection, equally gentle removal of a separating gangrenous slough, and the application of mild antiseptics often yield gratifying results. Here again, the intermittent venous occlusion apparatus is useful to assist in healing the residual granulating ulcer. (Fig. 4.)

True diabetic, or the so-called "wet" type of gangrene, is not essentially a problem of ischemia, and need not concern us here. It is infectious in origin, and has to do with the question of low local tissue immunity peculiar to diabetes. Its treatment and prognosis depend on the nature of the infection and the severity of the diabetes. Inadequate blood supply, of course, renders the condition more serious.

#### SUMMARY

1. Arteriosclerotic gangrene is a serious clinical problem with a high mortality.

2. One of the causes of this mortality is the failure to perform major amputation as soon as it is indicated.

3. The indications for, and the technique of, conservative treatment and surgical interference are discussed.

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# ADRENAL GLANDS AND MALIGNANCY\*

BORIS SOKOLOFF, M.D., SC.D.

AND

ISIDORE ARONS, M.D.

NEW YORK CITY

FIFTEEN years ago, a general opinion prevailed among the carcinologists that the endocrine system had no direct or even indirect connection with the evolution of malignancy. At that time, only a few, and most notably Dr. Leo Loeb, suspected that some of the hormones might have carcinogenic properties. During the intervening period, however, considerable material has accumulated strongly indicating that the endocrine system may be directly or indirectly involved in the process of neoplastic formation.

Lacassagne and Loeb, and after them numerous other investigators, demonstrated the carcinogenic activity of estrin. In certain strains of mice in whom mammary cancer occurs spontaneously in only a very small proportion of the females (2 to 3 per cent), the normal rate was increased by estrin injections to 60 per cent in both sexes.<sup>1</sup> An important observation has been recently reported by Geschickter, who was able to obtain, by injection of estrogenic substances, a large number of mammary adenocarcinomas in both male and female rats of a strain in which since 1934 no spontaneous cancer had been registered in a colony of 2000 animals.<sup>2</sup>

Corner suggested that the ovarian hormones act on the mammary gland through the intermediary of the anterior pituitary. Nelson<sup>3</sup> injected estrin and noticed a diminution in the number of basophiles in the pituitary and the disappearance of castration cells in the previously castrated animals of both sexes. He obtained a greater reaction in the female than in the male rats. Collip and his co-workers<sup>4</sup> found that administration of large doses of estrin to female rats led to a hypertrophy of the anterior lobe within a few days—an effect which was less marked in males and

in castrates. Other observers<sup>5</sup> found that estrin increased the weight of the pituitary in males, while McEuen, Selye and Collip<sup>6</sup> reported that adenoma formation sometimes occurred. According to Wolfe and co-workers,<sup>7,8</sup> the change caused by estrin treatment in the anterior lobe of the rat's pituitary is manifested in a degranulation of the eosinophile and basophile cells and in an increase in size and number of the chromophobe cells.

B. Zondek<sup>9</sup> observed that following prolonged administration of estrin the function of the anterior pituitary is inhibited. The gland becomes enlarged and increased in weight in males, while in females pituitary tumors may be observed. Cramer and Horning<sup>10</sup> reported that a prolonged application of estrin to mice resulted in functional inactivity, producing a condition resembling that following hypophysectomy; a hyperplasia of the anterior lobe was observed with noticeable diminution of chromophiles and increase of chromophobe cells. According to Burrow,<sup>11</sup> this hyperplasia occasioned by estrin could be observed in males only on rare occasions.

Halpern and D'Amour<sup>12</sup> observed that the administration of estrin causes an increase of 100 to 200 per cent in the weight of the hypophysis, produces hypertrophy and hyperplasia of the chromophobe cells, with increased mitosis. These effects were interpreted as an indication that estrin causes a release of gonadotropic hormones, and that when the secreting capacity of the gland is exceeded by demand, compensating hyperplasia of the primary cells results.

In general, a greater reaction takes place in the females than in the males. Thus, in large doses, hypertrophy of the anterior lobe is noted within a few days in females. Following prolonged administration of

\* Report to the Annual Meeting of the North American Radiological Society, November, 1938.

estrin there appears an enlargement of the pituitary with production of adenomata, an inhibition of the activity of the anterior lobe and of the growth and sex hormones.

Karlefors<sup>13</sup> in 1920 reported that in cancer (in man) the chromophobe cells of the pituitary were increased in size. Rössler<sup>14</sup> observed an increase in the eosinophiles in case of chorionepithelioma. Guyer and Claus<sup>15</sup> described changes in the anterior pituitary in rats who were bearers of Flexner carcinoma. The anterior pituitary was found to resemble that of castrated animals, with an increase in basophiles and with hyperactivity. These investigators concluded that changes are brought about by the influence of the growing tumor on the gland. When carcinoma is transplanted to the uterus, there is an increase in acidophile cells in the pituitary, resembling the phenomenon observed following estrin injections. Wyeth<sup>16</sup> found an increase in the eosinophile cells in the presence of human cancer. The gland is also heavier than normal (weight increase of 0.60 to 1.80 Gm.). Engel<sup>17</sup> recorded loose structure of pituitary in the majority of tumor mice. Mendeleef<sup>18</sup> concludes that pituitary hormonal activity increases during the evolution of a tumor and that the hypophyseal growth hormone is responsible for the continued proliferation of a neoplasm once this has been initiated. Lacassagne and Nyka<sup>19</sup> observed that after the hypophysis has been destroyed, rabbits appeared to be less susceptible to carcinogenic action of both tar and benzopyrine, as well as to inoculation with Shope papilloma. Samuels and Ball<sup>20</sup> confirmed this observation. They found that the pituitary is a factor in tumor growth, since hypophysectomy retards the growth rate of Walker carcinoma in rats and also slows the rate of growth of subcutaneous tumor induced by debenzanthracene.

Summarizing these observations we may say that there seems to be a definite increase of basophiles, as well as of pituitary hormone activity in malignancy, the reverse of which is observed under estrin therapy. Gonadectomy also leads to hyper-

trophy of the pituitary, with an increase of basophile cells and an increase in the gonadotropic hormones.

These observations are receiving particularly interesting interpretation in the light of the recently published work by Loeb and Kirtz.<sup>21</sup> The transplantation of anterior lobes of the hypophysis causes a marked development and secretory activity in the mammary gland tissue, both in strains with a high and with a low incidence of spontaneous mammary gland carcinoma. These transplants also cause a considerable increase in the cancer rate. The authors point out that the mechanism depends upon the coöperation of functioning ovaries, transplantation being entirely ineffective in ovariectomized mice. There is a possibility that the suppression of the luteal hormonal activity and the follicular hormonal overactivity is a contributing factor directly promoting growth processes in the mammary glands. In a number of mice which had received anterior lobe transplants there occurred, in addition to the mammary gland changes, precancerous proliferations in the vaginal-cervical tract.

In his previous work Loeb,<sup>22,23</sup> has established that ovariectomy causes a marked reduction in the incidence of mammary cancer. If in mice belonging to strains with a high incidence (almost 100 per cent) of mammary adenocarcinoma, the ovaries are extirpated at the age of 3 or 4 months, the cancer incidence falls to zero. These findings, confirmed by other workers (Cori, Lacassagne) are now interpreted as indicating that excess of follicular hormone, acting on the mammary gland, causes the transformation of normal mammary gland tissue into cancerous tissue.

Glandular imbalance, observed in mammary cancer, is not limited to the anterior pituitary and the ovaries. In 1929, Sokoloff<sup>24</sup> found that the adrenals of chickens who were bearers of Rous sarcoma, increased to from three to four times their normal weight. Some increase in the weight of adrenals was found in Flexner carcinoma rats and in sarcoma #180 mice. In 1934,

Tamura<sup>25</sup> confirmed these observations. More recently, Sure, Theis and Harrelson<sup>26</sup> found that in Walker carcinosarcoma

whether spontaneously in the females or in response to estrin in the males. This phenomenon was confirmed subsequently

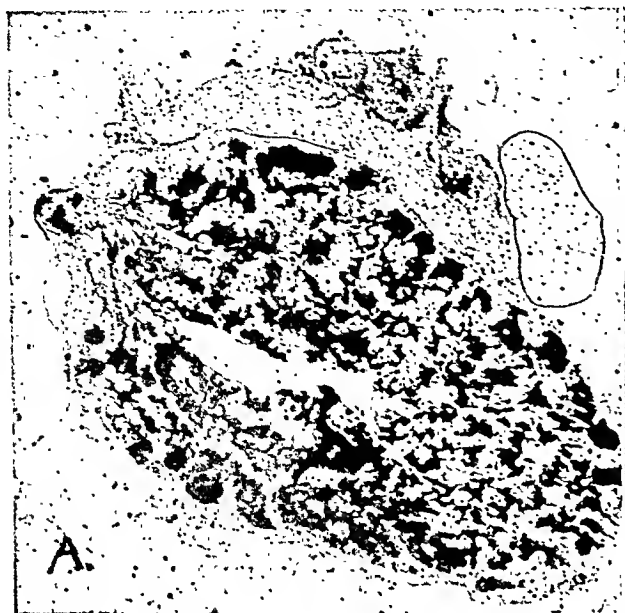


FIG. 1. Adrenal cortex of normal chicken (Sudan III).



FIG. 2. Adrenal cortex of Rous sarcoma chicken showing fatty degeneration (Sudan III).

the weight of the adrenal is almost doubled.

Okamoto<sup>27</sup> found that Kato rabbit sarcoma elicits proliferative changes in the adrenal cortex of rabbits and according to Oike<sup>28</sup> in tar cancer the adrenals of rabbits are greatly enlarged.

McEuen and Selye<sup>29</sup> and Sala and Stein<sup>30</sup> described a leucocytic infiltration of the adrenals of tumor-bearing rats, particularly in the zona fasciculata. This was thought to be due to the necrosis of adrenals.

Cramer and Horning<sup>31</sup> observed a brown degeneration in the adrenals of mice of mixed strains which had been painted with estrin. Isolated lipid-containing cells in the zona reticularis were enlarged and their contents were transformed into a brown material. Degeneration became more extensive during prolonged administration of estrogenic substances. Although brown degeneration did not occur in normal mice, it occurred spontaneously in male and female mice where there was a high incidence of mammary carcinoma among the females. The important point, according to these authors, is that these adrenal lesions fully developed *before* mammary cancer occurred,

by Lacassagne and Raynaud,<sup>32</sup> Burrows,<sup>33</sup> and Dobrovolskaia-Zavadskaia.<sup>34-35</sup> In a recent publication, Cramer and Horning<sup>36</sup> reported that in the two high cancer strains the brown degeneration began very early and after six months was present in all mice. Males and females of equal ages were found to be about equally affected. The brown degeneration affected not only the cortex but the medullary cells of the gland as well. They believe that "an impairment of the functional activity of the adrenal medulla favors the action of the ovarian estrogens on the mamma." Experiments on adrenalectomized mice had led them to the conclusion that "the hormonal functions of the adrenal cortex are synergic with the estrogenic functions of the ovary."

Ball and Samuels<sup>37</sup> found that the adrenals are enlarged in tumor-bearing rats. But in hypophysectomized rats bearing Walker carcinoma this hypertrophy of the adrenals was absent and, as is usual in hypophysectomized animals, atrophy of the adrenals was present. The authors conclude that the reaction of the adrenals to tumor growth is not a direct one but a reflection

of modification in pituitary hormonal activity in case of malignancy.

Reviewing these observations leads to an

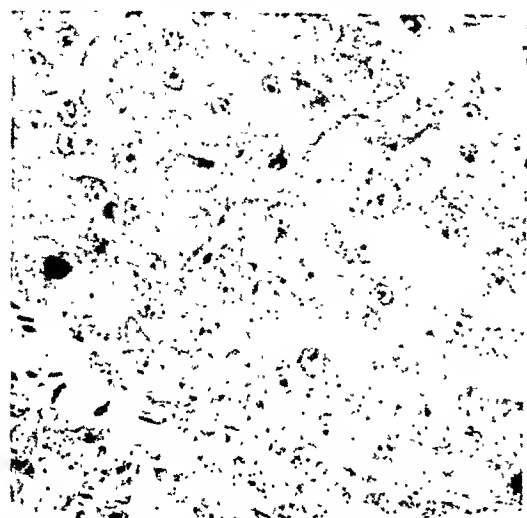


FIG. 3. Adrenal cortex of Rous sarcoma showing vacuolation of spongiocytes.

indication that in malignancy, as well as under estrin application, there occur histologic changes in the adrenals which seem to have a close interrelation with the reaction of the anterior pituitary.

Our study on this subject has been conducted for over a period of years, embracing extensive material. We have examined the adrenals of chickens, bearing Rous sarcoma; of rats, bearing Flexner carcinoma, sarcoma #39 and #10; and of mice, bearers of sarcoma #180.\*

TABLE I  
ADRENAL WEIGHT IN CHICKENS

Types	No.	Average Weight, Mg.
Normal.....	5	100.8
Small tumor.....	5	136.0
Medium tumor.....	10	169.0
Large tumor.....	10	332.0

The most striking changes were observed in the adrenals of Rous sarcoma chickens. With the progress and growth of tumor the

weight of adrenals steadily increased, reaching as high as four times the normal weight. (Table 1.)

The adrenal hypertrophy in tumor-bearing chickens affects chiefly the cortical part of the gland. (Figs. 1 and 2.) The cortical cells in malignancy are increased in volume, lose their typical structure and become filled with fat. The spongiocytes are in a state of vacuolization (Fig. 3), with picnotic nucleus and modified cellular structure.

The adrenals of tumor mice and rats show less pronounced increase in weight than in chickens. The average increase is about 80 to 90 per cent of the normal rate. Here there are two distinct stages of glandular reaction: cellular *hyperactivity* in the beginning of tumor growth, and *hypoactivity* and pathologic lesions in advanced malignancy.

In the adrenal of the female mouse the medulla and cortex are not separated by a defined band of connective tissue, as they are in the male. The juxtamedullary zone of reticular cells almost completely disappears when the males reach the age of two months but in the females it continues to growth until puberty, but it is here that the first cellular reaction to tumor growth is observed. The reticular cells, normally free of pigmentation, show the first signs of granulation and mitochondrial activity. The number of Altmann granules, which are considered as representing prelipoids, are also increased. Gradually, with growth of the tumor, the fatty degeneration is more pronounced, the Altmann granules disappear almost completely and the spongiocytes are filled with fat.

Soon after the transplantation of a tumor and with the first sign of the tumor growth there is an increase in the number of large reticulo-endothelial cells, particularly in the zone outside the medulla. With the progress of malignancy these cells disappear almost completely from the zona reticularis and only a few plasma cells are found. Intensive vacuolization of cytoplasm around the nucleus in plasma cells indicates a specific regressive process (Stoerk).

\* A large part of this work was done by one of us (B. S.) in Dr. Leo Loeb's Laboratory at Washington University Medical School, St. Louis.



Gradually, the zone fasciculata also shows a sign of degeneration. (Figs. 4 and 5.)

*Cortical Extract.* In 1930, Arloing, Jos-

Bilateral adrenalectomy was performed on thirty rats. Ten days after the operation, tumors were grafted (twelve rats with

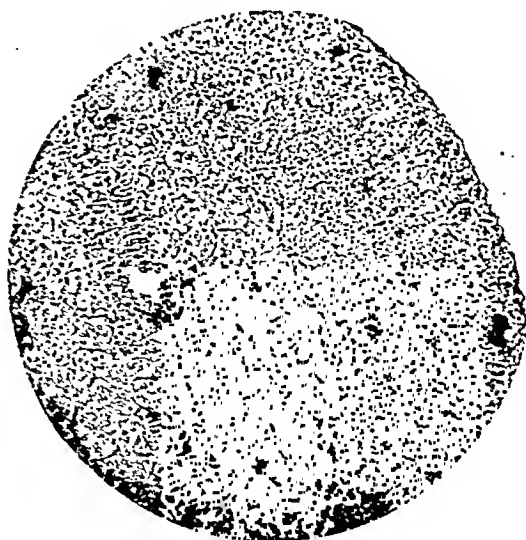
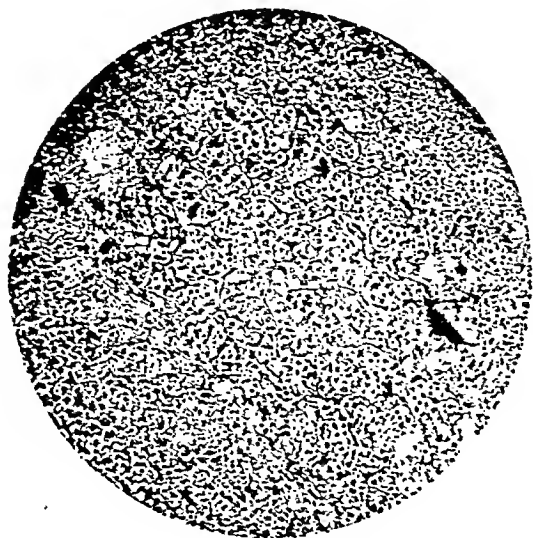


FIG. 4.

FIG. 5.

FIGS. 4 AND 5. Adrenal cortex of mouse with sarcoma.

serand and Charchon<sup>38</sup> found that adrenal cortex extract had inhibiting and even curative effects in malignancy, but a number of other authors<sup>39-41</sup> could not achieve these results. More recently, Beard<sup>42</sup> using concentrated cortical extract and suprascorin was able to obtain some inhibiting effect on the growth of Walker carcinosarcoma. We have found that Wilson cortical extract had no effect on sarcoma #180. Large doses of the same extract produced a slight inhibiting effect on Flexner rat carcinoma.

*Adrenalectomy.* Rogoff and others have demonstrated that bilateral adrenalectomy has a pronounced inhibiting effect on the growth of transplanted tumor. Tamura,<sup>41</sup> however, found only slight inhibition from destruction of both adrenal glands.

According to our experiments on twenty rats, unilateral adrenalectomy had no effect on the growth of sarcoma #39. The operation was performed at the same time when the graft of tumor was made. Bilateral adrenalectomy had a definitely inhibiting effect on the growth of Flexner carcinoma and sarcoma 39, if the graft followed the adrenalectomy.

Flexner carcinoma, eighteen rats with sarcoma #39). The animals were maintained on small amounts of suprarenal extract, injected subcutaneously. The adrenalectomized animals were rather apathetic and lacking in their usual vitality. Two animals died, probably from large tumors (sarcoma 39), and two others from infection. The rest seemed to show a strong resistance towards grafts. In the control animals, two rats out of eighteen showed regression of tumors, the remaining sixteen dying from malignancy.

Similar results have been obtained with Flexner carcinoma. Only in two instances out of twelve did the adrenalectomized animals die from malignancy.

In other series of experiments, in which the graft preceded adrenalectomy, the inhibition of the tumor growth was much less pronounced.

Considering the fact that bilateral adrenalectomy reflects considerably on the general condition of animals, the inhibiting effect of destruction of adrenals on tumor growth should be minimized. We know that the general well-being of the animal is an essential factor for successful transplanta-



tion of cancer. Nevertheless, adrenalectomy seems to have some inhibiting effect on tumor growth.

to seventy-two hours after the operation. Initial necrosis manifested itself in the center of the gland, then gradually ex-

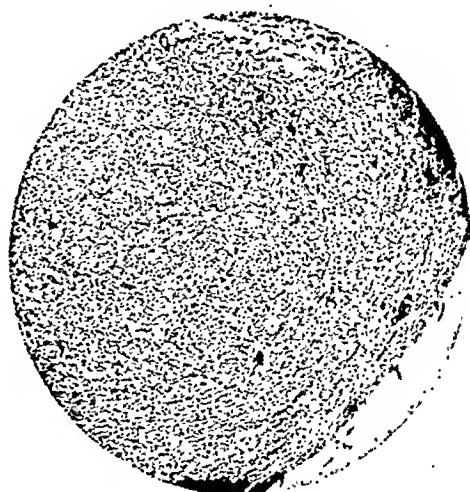
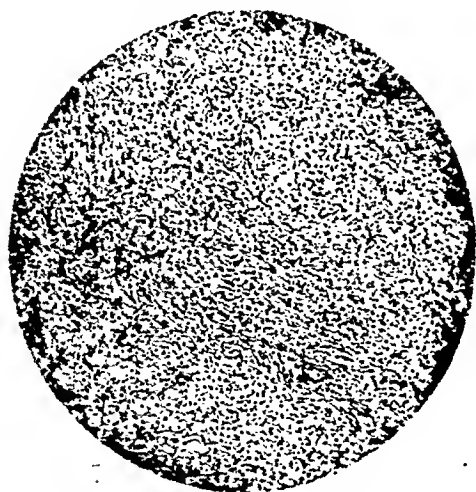


FIG. 6.

FIG. 7.

FIGS. 6 AND 7. Transplanted adrenal cortex showing initial necrosis (mouse).

*Adrenal Grafts.* Adrenals extirpated from brothers or sisters were transplanted to rats which had already been inoculated

tended peripherally. (Figs. 6 and 7.) Three days after grafting, the adrenal gland, except for the capsule and the exterior portion of the zona glomerulosa, was destroyed.

At about this stage the first signs of regeneration of the cortical tissue were noticed, but this regenerative activity of the cortical tissue was very small and the amount of restored cortex was rather insignificant.

We could not observe any noticeable effect of the grafting on the growth of the tumor. In three cases there was some inhibition of tumor growth, but this was only temporary.

Studying the regeneration of cortical tissue of grafting adrenals, we found considerable difference in regenerative power, depending on the progress of malignancy. In those cases where the animals had small incipient tumors, the adrenal transplant showed much less regenerative activity. In cases where the adrenals were grafted in animals with large tumors, the regenerative process was much more extended. The organism of animals affected with advanced malignancy must have some physiologic

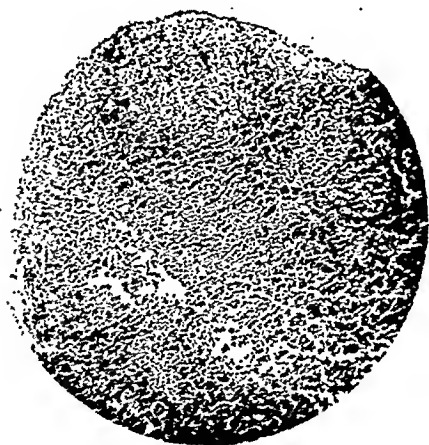


FIG. 8. Initial necrosis.

with sarcoma #39 (thirty rats) or Flexner carcinoma (twenty rats). The adrenal gland was transplanted either to ovaries or intracutaneously.

As a rule, degeneration of the transplanted gland followed within forty-eight

need for the biologic principle elaborated by the adrenal gland. The function of the adrenal cortex seems to be in a suppressed stage in cases of advanced malignancy.

Recently Wyman and Soden<sup>43</sup> concluded from a series of their studies on adrenal grafts that survival of a graft depended on the presence of the pituitary adrenotropic principle. They expressed the belief that this was used in the growth and maintenance of the normal adrenals, and thus adrenal grafts without available adrenotropic principle failed to survive. Their theory finds confirmation in the recent work of Ingle.<sup>44</sup>

#### DISCUSSION

Regaud pointed out that in all probability a state of hyperactivity of some glands precedes the appearance of malignancy. Yet the nature and character of this glandular dysfunction has not been clearly defined. However, it is a well established fact that prolonged application of estrin inhibits the activity of anterior pituitary, including the production of the growth and sex hormones. Should we therefore consider estrin over-production as a potential precancerous state, since estrin has definite carcinogenic properties?\*

Some evidence in support of this theory was brought out in the recent work of Leo Loeb, who found that anterior pituitary transplants increased the incidence of mammary gland carcinoma in inbred strains of mice. However, the transplants of hypophysis were completely ineffective when the ovariectomy preceded the transplantation. Thus, Loeb concludes, the growth-stimulating effect of anterior pituitary transplant on the mammary gland is not direct but through the ovaries, in all probability through the corpus luteum.

Corpus luteum seems to have an inhibiting effect on the growth properties of es-

trin. Thus we may visualize that an increase of anterior pituitary's activity may result in suppression of corpus luteum and deliberation of estrin-growth-stimulating factor.

These experimental data might be of considerable importance in cancer therapy, particularly in the case of malignancy of the mammary gland or uterus. They would suggest a sterilization in the earliest stage of malignancy as the most rational method of prevention of recurrence of growth.

The functional relations between the adrenal cortex and gonads are very close. The most striking fact in this relationship was brought out by Rogoff<sup>45</sup> who showed that pregnancy has a marked influence in dogs in prolonging the period of survival and maintaining good health after the removal of adrenals. The corpus luteum can presumably contribute something to make up for the loss of the adrenals. Goormachtich<sup>47</sup> recently suggested that the juxtamedullary cells of the adrenal and the luteal cells of the ovaries have something in common. Every change in the activity of the gonads reflects on the adrenal cortex, and vice versa. In B-avitaminosis, the adrenals may be enlarged from five to seven times, there may also be a striking atrophy of the gonads (in pigeon).

Thus the question arises, what rôle, if any, does the adrenal gland play in malignancy? Cramer found that the adrenal cortex of mice with a high incidence of mammary carcinoma has pathologic lesions which could not be observed in normal mice and which preceded the appearance of malignancy. Tamura confirmed the observation of one of us (Sokoloff) published some years ago, that the weight of the adrenal gland is increased in malignancy. A number of other authors have recently described various histologic changes in the adrenal cortex of cancerous rats and mice.

Analyzing our material on this subject, we found that there are at least two different cellular reactions of adrenal cortex to tumor growth. In the precancerous state

\* Biologically, the suppression of growth hormone could be responsible for abnormal cellular multiplication. Suppression of the growth of cell increased the dynamic properties of its nucleus. According to Sokoloff,<sup>45</sup> the nucleocytoplasmic ratio of cancer cells of incipient growth is considerably increased.

there exists in the reticular zone of the adrenal cellular stimulation and glandular hyperactivity. In advanced malignancy, there is cellular degeneration and glandular hypofunction.

These experimental findings seem to be in accord with clinical observations on cancer patients. The feeling of well-being and even of unusual energy, which has often been noticed in patients with incipient cancer, is soon replaced by a feeling of extreme fatigue which often cannot be explained by anemia or toxemia, but may well be accounted for by the presence of lesions in the adrenal. We have, however, no proof that these adrenal lesions are contributing factors to the progress of malignancy. They may be nothing but a reflection of gonadopituitary dysfunction. And even the fact that bilateral adrenalectomy considerably inhibits the growth of transplanted tumor does not necessarily prove that the adrenal plays an active rôle in cancer. Only one statement may be made safely at present: that in malignancy cortico-adrenal imbalance is present.

#### SUMMARY

The interrelation between tumor growth, the anterior pituitary, and the adrenal glands is discussed.

The histologic changes in the adrenals of chickens, rats, and mice, bearing tumor, have been studied. The weight of adrenal glands is increased in cancerous animals, particularly in chickens with Rous sarcoma.

Two stages of cellular reaction have been found in the adrenal cortex, hyperactivity of the zona reticularis, in incipient malignancy, and lipoid accumulation and fatty degeneration of the cortical part, similar to B-avitaminosis in large tumors. These two stages probably correspond to two different stages of glandular activity: hyperactivity of the adrenal cortex in the beginning of malignancy and hypofunction with the progress of tumor growth.

Unilateral adrenalectomy seems to have no effect on the growth of transplanted

tumor. Bilateral adrenalectomy has a definite inhibiting effect upon it.

Grafting of adrenal tissue does not produce any noticeable effect on tumor growth.

The regenerative power of the cortical tissue is more pronounced in grafts in rats with large tumors than in non-cancerous rats. This suggests that the organism affected by cancer must have some physiologic need for the biologic principle elaborated by the adrenal gland.

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# A STUDY OF SIXTY CASES OF TETANUS\*

JAMES A. KIRTLEY, JR., M.D.

Instructor in Clinical Surgery, Assistant Visiting Surgeon, Vanderbilt University School of Medicine

NASHVILLE, TENNESSEE

THE mortality of tetanus today is just about what it was before specific antitoxin was developed. Graves and Hessart found the mortality in the pre-antitoxin era to be between 41 per cent and 84 per cent, or an average of 62.5 per cent.<sup>4</sup>

A recent study of 642 cases of tetanus by Huntington and his co-workers showed the total mortality to be 63 per cent.<sup>3</sup> These cases were collected from the Barnes Hospital, St. Louis Children's, Massachusetts General, Johns Hopkins, University of Pennsylvania, Presbyterian and Bellevue in New York, Boston Children's, and several others. Many other recent authors report mortality rates varying from 40 per cent to 72 per cent.

TABLE I

	No. of Cases	Deaths	Per Cent Mortality
Acute.....	32	23	71.8
Chronic.....	28	5	17.8
Combined.....	60	28	46.6

Acute—incubation period of ten days or less.

Chronic—incubation period of more than ten days.

A series of fifty-two cases of tetanus in the Vanderbilt University Hospital and eight cases in St. Thomas Hospital were studied, covering the past fourteen years. Two very doubtful cases and one case in which death probably resulted from other injuries and complications were excluded. The cases were arbitrarily divided into two almost equal groups according to the incubation period. Those patients whose symptoms appeared within ten days after the initial injury were classified as having early tetanus, while those with an incubation

period of over ten days were termed late tetanus. The mortality of the early cases was 71.8 per cent, while the mortality of the late cases was 17.8 per cent. (Table I.) The mortality for the entire group was 46.6 per cent. There was almost an equal number of early and late cases.

There was no uniform method of treatment given all patients, as they were admitted on the pediatric, medical or surgical services of these two hospitals.

Puncture wounds of the extremities were the most frequent injuries. Nails, splinters, thorns, and rake prongs were the commonest agents. Lacerated wounds were the next most frequent. There were three cases in which a toe or finger was mashed, but only a contused wound sustained. Two of these patients died.

TABLE II

Year	No. of Cases	Deaths	Per Cent Mortality
1925-1931.....	24	11	45.8
1932-Oct., 1938.....	36	17	47.2

The mortality rate from year to year shows little change. The mortality rate in 1925 was 75 per cent and again in 1938, with an equal number of cases, 75 per cent. During the first seven-year period studied the rate was 45.8 per cent in a total of twenty-four cases. In the past seven years the mortality has been 47.2 per cent, with a total of thirty-six cases. (Table II.)

Three patients out of the sixty studied received prophylactic injections of at least 1,500 units of antitoxin within twenty-four hours of the initial injury. Two of these patients died and one recovered. It may be

\* From the Department of Surgery, Vanderbilt University Medical School, Nashville, Tenn.

significant that all three of these patients had sustained fractures, two of them being compounded. There was soft tissue injury and wound conditions favored anaerobic organisms in these two cases.

TABLE III

Site of Injury	No. of Cases	Deaths	Per Cent Mortality
Face.....	3	2	66.6
Upper extremity.....	11	7	63.6
Umbilicus.....	3	2	66.6
Uterus.....	2	1	50
Lower extremity.....	41	16	39
Total.....	60	28	46.6

Klopp of the Episcopal Hospital in Philadelphia studied fifty-two cases of tetanus.<sup>2</sup> Of these five had received prophylactic antitoxin, but four of them died later of tetanus.

It is generally assumed that prophylactic antitoxin will entirely prevent tetanus, but 5 to 10 per cent of the patients with

TABLE IV

Age	No. of Cases	Deaths	Per Cent Mortality
0-5.....	15	7	60
6-15.....	25	9	36
16-55.....	17	7	41.1
56-70.....	3	3	100
Total.....	60	28	46.6

tetanus have had prophylactic antitoxin. The strongest evidence for prophylaxis is the low incidence of 0.117 per cent of tetanus in over two million wounded British soldiers who had received antitoxin.<sup>4</sup> The practice of debriding and irrigating many of these war wounds may also have been a big factor in lowering the incidence of war tetanus. The incidence of tetanus has steadily decreased with each war as medical care and prophylaxis have improved.

Comparable figures in civil life are not available. Certainly there are many people who sustain the same type of injuries found in this series who do not receive antitoxin and do not develop tetanus. Since antitoxin

TABLE V

Type Wound	No. of Cases	Deaths	Per Cent Mortality
Puncture.....	28	11	39.2
Incised.....	9	4	44.4
Lacerated.....	12	5	41.6
Contused.....	4	3	75
Gunshot.....	1	1	100
Septic.....	5	3	60
Burns.....	1	1	100

has not materially decreased the mortality of tetanus, a critical study of the value of prophylactic antitoxin is indicated.

Considerable work on tetanus toxoid has been done during the past few years and reports indicate that it may supplant the tetanus antitoxin derived from horses and cows, thus avoiding serum reactions. The

TABLE VI

Units A.T.S. Received First 48 Hours after Admission	No. of Cases	Deaths	Per Cent Mortality
None.....	3	2	66.6
(x)-Phenol intra. "v".....	1(x)		
None to 10,000.....	13	6	46.1
10,000 to 25,000.....	10	6	60
25,000 to 50,000.....	18	7	38.8
50,000 to 100,000.....	16	7	43.7
Total.....	60	28	46.6

alum precipitated toxoid seems to confer an active immunity after several weeks and will probably be combined with antitoxin in the future. It is being administered with typhoid vaccine in certain divisions of the French and English armies. Its action is too slow for the treatment of acute tetanus, but would seem indicated as a prophylactic measure in compound fractures, gunshot wounds, or before some old traumatic wound is reopened.

## Kirtley—Study of Tetanus

The importance of incising the site of infection and removing all foreign material when present has been urged by many writers. At the Charity Hospital in New Orleans all tetanus cases are sent to the operating room before admission to the wards. Gage and DeBakey report a mortality of 20 per cent in a series of fifteen patients so treated.<sup>4</sup>

TABLE VII

	No. of Cases	Deaths	Per Cent Mortality
Wounds treated surgically.....	7	1	14.2
Wounds not treated surgically.....	53	27	50.9
Total.....	60	28	46.6

In this series some surgical procedure was instituted in seven cases with one death (mortality 14.2 per cent). There were fifty-three patients whose wounds did not receive any surgical procedure, with twenty-seven deaths (mortality 50.9 per cent). (Table VII.) Three of the seven patients who had incision and drainage of the initial wounds had a foreign body in the wound, three had a localized abscess requiring drainage, and the seventh patient had a suppurative arthritis of the knee joint following an incised wound (ax) one month previously. Open drainage of the joint with resection of the articular surfaces was done and thirteen days later tetanus developed along with high fever. The patient died five days later of tetanus. Autopsy showed some necrosis of the bony surfaces of femur and tibia.

One patient who had several foreign bodies in a wound developed tetanus following a fall on a gravel path. The abrasions apparently healed and the patient received a total of 250,000 units and avertin and left the hospital a month after the injury. After being up for several days, abdominal rigidity, trismus and convulsions recurred. There was some swelling about

the initial abrasion and a small abscess cavity containing two pieces of gravel was incised and drained and the rigidity cleared up in several days without further treatment. This case illustrates the transient, and even questionable value of antitoxin, since this boy had 250,000 units and yet several days later developed tetanus again when there was a flare-up in the original

TABLE VIII  
SURVIVAL PERIOD IN HOSPITAL  
Time of Deaths

	No. of Cases
1-24 hours.....	10
24-48 hours.....	5
3 days.....	6
4 days.....	3
5 days.....	1
6-16 days.....	3
Total.....	28

wound. Removal of the gravel when the patient was first seen probably would have decreased the amount of expensive antitoxin used as well as the time in the hospital, and have prevented the recurrence.

The importance of the wound care is again emphasized in the one patient of the sixty who would have been expected to die but recovered. This boy of 10 cut his leg on a piece of glass and the wound was sutured at once. Three days later (shortest incubation period in the group) trismus and convulsions developed. The wound was reopened, irrigated and wet dressings applied. The child had high fever, tachycardia, and all the unfavorable prognostic signs, but did recover.

Failure to drain a localized infection containing tetanus bacilli may result fatally in spite of long incubation and survival periods and over 200,000 units of antitoxin. A boy of 17 injured his hand with a blank cartridge and a week later developed mild tetanus and entered the hospital. He received large daily doses of antitoxin, but became progressively worse and died sixteen days after admission. Autopsy showed a palmar abscess containing powder granules, pus, and tetanus spores.

Twenty of the twenty-eight patients who died had wounds so located that incision or



excision could have been done. Half of these died within twenty-four hours after admission, however, so it is questionable whether any measure would have been of benefit. The other ten patients lived from two to sixteen days. (Table VIII.)

It would seem desirable to incise the infected wound and convert it into an open wound in which anaerobiosis would be discouraged if not prevented. If further toxin formation can be prevented after admission to the hospital and the free, unfixed toxin neutralized, some of the patients who live four or five days in the hospital may be saved.

Of the four possible modes of administration of antitoxin the intravenous and intramuscular routes are preferable. There is little evidence to show that intraspinal injection of antitoxin decreases mortality, and Wainwright states that "the best way to increase the mortality of tetanus is to give the antitoxin intraspinally."<sup>4</sup> In this series antitoxin was given intraspinally in so few instances that conclusions as to its value cannot be determined.

The amount of antitoxin given seems to make very little difference in mortality. Deaths were slightly less in the group receiving 25,000 to 50,000 in the first forty-eight hours. (Table VI.) Over half of the deaths occurred within twenty-four hours after admission to the hospital. All but two of these fifteen, however, received over 10,000 units on admission. Over 43 per cent of all patients who died received more than 50,000 units within a few hours after admission.

In this series avertin was used only in those patients having clonic convulsions; half recovered and half died. Both experimentally and clinically, convulsions seem to hasten the spread of toxin and their abolition would therefore seem important. Avertin is probably the best basal anesthetic available at present.

Phenol intravenously was given to seven of the sixty patients, with two deaths. The two who died had short incubation, while those recovering had incubation periods of over ten days. One patient with an incubation period of sixteen days received phenol alone and recovered. No one has ever repeated the excellent results obtained by Bacelli with the use of phenol.

Almost half of the wounds were puncture wounds, but incised wounds had a higher mortality. (Table V.) Many of these incised wounds had been sutured, or at least seen by a physician. There were three cases of tetanus neonatorum with two deaths. Two cases of tetanus followed attempted abortion. (Table III.) One was produced with a chicken feather and this patient died on the ninth day; the other patient recovered.

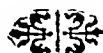
Certain signs and factors indicate a grave prognosis. A few are briefly listed: (1) an incubation period of less than a week, (2) wounds on the face, trunk, and upper extremities; (3) high fever and tachycardia; and (4) convulsions.

#### SUMMARY

Sixty cases of tetanus with a mortality of 46.6 per cent are presented. Prophylactic antitoxin did not prevent tetanus in 5 per cent of the cases. Patients receiving some surgical treatment of the infected wounds were four times as likely to recover as those not receiving any surgical care. The immediate administration of 50,000 units of antitoxin intravenously and the simultaneous administration of toxoid at five day intervals for two doses would maintain the blood antitoxin level at an adequate level.

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# LOCAL ASPHYXIA AND TUMORS

FREDERICK M. ALLEN, M.D.

NEW YORK CITY

THIS research originated as one phase of a frustrated investigation of circulatory and vascular disturbances. The production of diabetes by the inflammation following temporary ligation of the pancreatic vessels was first reported,<sup>1</sup> and chronic hypertension was obtained with similar treatment of the kidneys<sup>2</sup> prior to the work of Goldblatt.<sup>3</sup> The tumor research would have been facilitated if other parts of the general investigation could have been finished.

About 1917, when the lymphocytic theory<sup>4</sup> of tumor defense was prominent, the writer mentioned to Dr. J. B. Murphy the intention of trying to excite a local tissue reaction around tumors. This field is still untouched. Bowen's<sup>5</sup> permanent ligation of the blood supply to the tumor region is entirely different, and Lumsden's<sup>6</sup> temporary ligations were made for testing the effects of a serum and were continued only for two hours, so that the full effects of asphyxia were missed. Sufficiently prolonged asphyxia of a typical viscus such as the kidney or testis produces complete atrophy and sclerosis, the parenchymal cells dying first, presumably because of their specialization or high metabolism, while the connective tissue of supposedly lower metabolism survives. In applying this method to tumors, the question arises whether the tumor cells will die quickly because of their high metabolic activity with the accompanying need for oxygen and accumulation of lactic acid<sup>7</sup> and other products, or whether their capacity for anaerobic metabolism<sup>8</sup> will endow them with a special resistance to asphyxia, or how they will be affected by the high oxygenation<sup>9</sup> of the blood during the subsequent reactive hyperemia or by the local metabolic conditions of inflammation.<sup>10</sup> Second, owing to the importance of the tumor stroma, there

are questions of the influence of capillary hemorrhages, round cell and leucocyte invasions and fibrosis, all of which can be produced by asphyxia and which are commonly associated with tumor regression. Finally, the altered interchange between tumor cells and blood, the stimulation of local or general immunity reactions,<sup>6,11</sup> and many indefinite possibilities may be considered in relation to any possible theories of tumor growth.

## PLAN AND METHODS

This work has involved the use of several thousand animals, chiefly rats, and has extended over ten years. Tumor-bearing animals for starting the various mammalian tumor strains mentioned were purchased from the Crocker Institute. Except as otherwise mentioned, the tumors were implanted in the lower thigh or upper calf. The use of rubber bands as tourniquets, and the reactions in normal animals, comprising hyperemia, paralysis, shock, the endurance of asphyxia by limbs and viscera, the influence of temperature, and numerous other details have been described in a series of previous papers.<sup>12</sup> The results are here presented in compressed summary.

*I. Immediate Effects of Asphyxia.* 1. *Reaction of Hemorrhagic Congestion.* With a tumor in the usual location under the skin or amid the muscles, ligation of a leg is followed by a striking circulatory reaction. The pink hyperemia of the normal parts changes to more or less of a bluish tinge over the tumor. After the longest ligations, when the color of the foot is a rather bright red, the tumor area shows a deeper blue, darkening gradually to almost black. Incision shows that the normal parts are edematous and also surcharged with bright arterial blood. On the contrary the tumor is swollen and darkly engorged. This in-

tense hemorrhagic congestion may involve the entire tumor tissue but is not confined strictly to it, for the maximum engorgement is often found in a narrow zone comprising the outermost layer of the tumor and a very thin layer of surrounding tissue. This reaction, in its striking contrast of blue against red, may be somewhat less readily induced in certain locations such as the foot or groin, but in general it seems to be a constant characteristic of all the tumors studied, in comparison with the normal peripheral tissues of the body.

2. *Necrosis of Tumor Tissue.* Typically, the dark blue color acquired by the tumor soon after release of the ligature changes gradually in the course of a few hours to black, and if the ligation has been present long enough the tumor softens and sloughs out partially or completely. This process naturally occurs most readily in the center of the tumor mass, where the nutrition is poorest. The better nourished peripheral layers, though they may have been most deeply congested, survive much more stubbornly and often continue to grow around the margins of the ulcer. Not only partial but also complete destruction is produced somewhat more easily in large tumors than in small ones, for one of two hypothetical reasons: (a) the enzymes and toxic products from the dead central part may poison the outer layers; (b) the small tumors may be in closer relation with a normal blood supply, while larger tumors may be more dependent upon their own vascular apparatus, which is insufficient and breaks down under congestion. The normal tissues meanwhile display merely edema and inflammation, and unless the ligation is carried to the extreme of producing general gangrene, there is always a sharp demarcation between the necrotic tumor and the inflamed surrounding tissue.

3. *Metastases.* From the outset, the possibility was borne in mind that a procedure which produces such marked hyperemia and edema may conceivably augment the metastatic transport of tumor cells, either through the blood stream or through the

lymph. The impression gained from hundreds of observations is that such an occurrence is absent or slight. Tumors subjected to various degrees of partial damage by ligation have apparently not metastasized sooner or more extensively than untreated tumors. Complete destruction of a tumor has been followed by metastases only when there was reason to suspect a transportation of tumor cells prior to the ligation. Doubts of the absolute validity of these statements have arisen only lately in regard to the Walker tumor, and can perhaps be explained on the assumption that the growth of existing metastases may be accelerated when the original tumor is nearly or completely destroyed.

11. *Results in Mice.* Experiments were undertaken with three tumors from the Crocker Laboratory, namely the sarcoma 180, a carcinoma and a chondroma. Owing to unfavorable conditions the mortality among mice was so high that this phase of the work was curtailed. All tumors were allowed to grow to 0.75 to 1.0 cm. diameter before treatment.

The reaction of hemorrhagic congestion was very marked, and ligations of three to four hours, or sometimes as short as two hours, resulted in complete necrosis and healing without recurrence, in the case of the sarcoma and carcinoma. It would have been desirable to repeat these results in more numerous mice of different strains and at different seasons, in order to establish more positive conclusions.

The chondroma is known as a tumor with nearly 100 per cent of "takes," a very slow growth rate, and benign character, which finally proves fatal through mere increase in size. Hemorrhagic congestion following ligation seemed to be distinctly less than in the preceding tumors. According to Neuberg and Caspari,<sup>13</sup> chemotherapy also causes less congestion, hemorrhage and necrosis in benign than in malignant tumors. This tumor survived longer asphyxia than the preceding ones, and the exact time requirement was not established. The surviving tumors could be killed by

successive repetitions of ligation, so that no actual failures were encountered when the animals lived long enough.

It is open to speculation whether the differences between the malignant and benign mouse tumors, also between mouse and rat tumors, are connected with rapidity of growth, metabolic activity, vascular fragility or other characters.

*III. Single Ligations in Rats.* The tumors used were the Flexnor-Jobling carcinoma, the Crocker sarcoma 39, and the Walker tumor. Treatment was given when they had reached a diameter of 1.5 cm. or considerably larger. The dangers from shock, ulceration, infection and cachexia increase with the size of the tumor. All these troubles would be less with tumors of similar size in a larger species, but in the rat the mortality from these accidental causes multiplies the labor of obtaining a sufficient series of survivals for a convincing length of time.

Large tumors were used in the face of these difficulties for two reasons: (a) because the attempt to cure a well advanced malignant growth is believed to be the best test of any treatment, and (b) as assurance against spontaneous recessions.<sup>14</sup> Tumor specialists estimate standard percentages of recessions for different tumor types, in a traditional location along the side of the body. It is likewise evident that these tumors grow in a nodular mass almost separate from the body, where they can receive nutrition only from tiny subcutaneous vessels and a thin layer of superficial muscles. Recessions are thus so readily accounted for by mechanical deficiencies of circulation that it is only surprising that they are not more numerous. Tumors in the mesentery or omentum generally grow from only a narrow pedicle and thus are still more subject to necrosis, often having only a thin shell of living tissue which is perhaps nourished by lymph diffusion and which is likely to be found non-transplantable. On the contrary, a tumor well established in the liver, kidney or spleen of a rat, with an abundant blood supply, has less necrosis

and is never cured by any spontaneous process. Leg tumors have available nutrition from larger muscles and blood vessels, and they are compressed by the tighter skin so that they grow from a broader and firmer base than axillary tumors. The present experience is believed to be large enough to support the declaration that tumors of the kinds here described are practically free from spontaneous recession, and that the figures given for cures are absolute and not subject to statistical revision.

TABLE I  
RESULTS OF LIGATION OF RAT TUMORS

Tumor	No. of Rats	Hours of Ligation	Results	
			Recur- rence	Permanent Cure
Sarcoma	42	5	16*	26
	31	6	7	24
	23	7	0	23
F-J carcinoma	37	5	27	10
	33	6	15	18
	19	7	0	19
Walker tumor	18	5	18	0
	16	6	15	1
	14	7	8	6
	9	9	0	9

\* In 3 of these cases, a second five-hour ligation brought complete cure.

With the tumor in the lower part of the thigh, a tourniquet about the upper thigh can be tolerated for several hours without fatal shock. For longer ligations it is necessary that the tumor be in the foreleg or foot, so that the tourniquet can be placed lower. Previous papers have shown that it must be placed below the knee in order to avoid fatal shock for periods long enough to test the maximum endurance of asphyxia by normal tissues. The normal tissues can thus survive approximately 13 hours of deprivation of circulation, and there are plain signs that they could survive several hours longer except for the secondary consequences of ulceration and thrombosis at the ligature site, which are more

serious in rats than in larger species. A tumor-bearing leg cannot survive more than eleven or rarely twelve hours of ligation, because the ulcerating tumor opens a channel for infection which the damaged normal tissues cannot resist. Also the longer the ligation the greater is the tendency of rats to gnaw the anesthetic limbs. It was sometimes necessary to prevent this, and also the trauma of dragging the legs around, by confining them for several days in individual boxes too narrow to permit turning.

Repetitions of the experiments in an attempt to increase the proportion of cures gave a considerably poorer result than that shown in the table. Many such series were carried out with irregular results, which seemed to vary with the season, with different strains of rats, or other unknown variables. Lengthening the time of ligation beyond seven or eight hours yielded no benefits to compensate for the increased danger. This result is in harmony with the view that the curative process consists not in direct asphyxial injury of the tumor cells but in a special vascular or tissue reaction.

No plan of ligation was ever found which cured more than a variable and sometimes small minority of rat tumors. The differences in resistance of the three tumor types were uniform, in that the sarcoma 39 was least resistant, the Walker tumor most resistant, and the F-J carcinoma intermediate. The Walker tumor may have undergone changes;<sup>15</sup> it was totally incurable by ligation in the later stages of the work.

The manner of tumor death by dark hemorrhagic congestion and abrupt sloughing is entirely different from spontaneous recession. The center of any large tumor breaks down with the briefest interruption of the blood supply. The peripheral layers are more resistant in proportion as they are better nourished. After long ligations, when no tumor tissue can be found in the ulcer by gross inspection, nests of cells are sometimes found microscopically adjacent to normal tissues. Serial sections were never made, but after some of the longest ligations ordinary slides failed to reveal any

living tumor. The smallness of the residue was further demonstrated by the fact that the ulcer sometimes healed completely or almost completely before a recurrence appeared. The inflammatory picture following ligation was such that one pathologist accustomed to tumor studies assumed at first glance that it was the result of a heavy x-ray dose. The results were apparently not due to accumulation of any special type of defensive cells, as the tumor death occurred suddenly before any such accumulation was possible. One possible interpretation is that the tumor stroma easily breaks down, and that the most resistant tumor cells are those which are still supplied from normal blood vessels by reason of their contiguity to normal tissues.

*IV. Repeated Ligations.* The production of diabetes by progressive injury of the islands of Langerhans, and of chronic hypertension by nephrosclerosis, are examples of the degenerative and sclerosing effects of repeated brief clamping of the blood vessels of viscera. It was hoped that some such effects might be produced by repeated ligations of tumors; in particular, that a gradual sclerosis or some closer imitation of spontaneous recession might thus be obtained instead of the sudden necrosis which follows a single long ligation. As any ligation plainly damages a tumor out of all proportion to the normal tissues, there was reason to hope that repetitions of the process would increase this selective effect and also reduce the dangers. Also edema, hyperemia, cellular and tissue reactions, etc., may be kept active over a longer time by repeated than by single ligations.

Preliminary experiments comprised ligations of legs of normal rats for longer or shorter periods at intervals of hours or days during several weeks. The main outcome was that the peripheral tissues proved to be much more resistant to this process than the viscera; the desired tumor treatment is thus feasible without serious injury of the normal parts. A former plan of trying to produce chronic local edema or sclerosis in larger species could not be carried out. In

rats such an attempt encounters the difficulty that the skin is the point of lowest resistance, and the experiments when pushed too far are stopped by ulcerations. Minor degrees of permanent atrophy of the limb were sometimes produced. Naturally, short ligations can be repeated at the shortest intervals, while long ligations require correspondingly lengthened rest periods.

Rats bearing the three types of tumors, which escaped accidental death and survived long enough for complete judgment of the results, were divided into four groups as follows:

1. Short ligations (fifteen to forty-five minutes) with relatively long intervening periods (one day to one week); twenty animals. These attempts to excite slight recurrent hemorrhages, cellular reactions or fibrosis in tumors were soon abandoned, because the tumors merely ulcerated while continuing to grow rapidly.

2. Longer ligations (one to four hours) at long intervals (one to two weeks); forty-four animals.

3. Long ligations at shorter intervals (one to three days); fifty-nine animals.

4. Eccentric ligation periods, beginning with short and increasing to longer times, or vice versa, and repeated according to the apparent limit of the individual rat's strength.

The tumors thus treated all ulcerated but continued to grow. No fibrosis and nothing resembling spontaneous recession was ever produced. As these rat tumors are practically never (only three instances in this entire research) killed by a single ligation of less than five hours, so also ligations of four or four and one-half hours, repeated one to four times or as often as the rat's strength permitted, were followed only by more or less complete exulceration and later recurrence. The failure to obtain a single cure in these series adds to the evidence that tumors of this size are dependable test objects and that cures when obtained are genuine.

Near the close of the research, attention was given to the possibility that the failures

in these attempts might be explainable by unduly long intervals between the ligations, allowing time for the active inflammation to subside. A fifth series was then undertaken, with ligations of one-half to one and one-half hours' duration, repeated at intervals of one to two hours throughout two days. In this way six cures were obtained among fifteen tumors. Furthermore, certain of these tumors were as large as 3 cm. in diameter—larger than can be treated successfully with single ligations because of the danger of shock. The successes were all among the sarcomas and F-J carcinomas. All the Walker tumors finally recurred. The inflammation of the normal tissues and hemorrhagic congestion and necrosis in the tumor were the same as with single long ligations. It was impossible to make up a larger series because of the ending of the research. The method seemed to promise better success and greater safety than single long ligations. Its theoretical importance is as evidence that prolonged continuance of asphyxia is not a necessary condition for tumor destruction.

#### SUMMARY AND CONCLUSIONS

This paper describes the effects of local asphyxia upon transplanted tumors of rats and mice located in peripheral regions such as the limbs.

1. The first effect is the so-called reaction of hemorrhagic congestion, in which the tumor turns dark blue in contrast to the bright arterial hyperemia of the surrounding normal tissues.

2. Subsequently, the tumor undergoes extensive or complete necrosis, actual cures by this process being more frequent in mice than in rats.

3. These results of prolonged single ligations can be duplicated or even improved by suitable repetitions of brief ligations. The most important theoretical deduction is that the tumor death is not due to the simple duration of asphyxia or toxic action of accumulated asphyxial products.

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# SPASMODIC TORTICOLLIS: ITS CAUSE AND TREATMENT\*

J. TORRANCE RUGH, M.D., LL.D.

PHILADELPHIA, PENNSYLVANIA

A STUDY of the literature of so-called "spasmodic torticollis" reveals confusion and uncertainty as to its



FIG. 1. Cast as applied.

etiology as well as hopelessness in the prognosis and treatment. Neurologists and neurologic surgeons have failed to agree as to the character and location of the processes in the brain, responsible for the external evidences of the dystonic disturbance. However, other facts arrest the attention, especially the clinical descriptions of the affection and the reports of the pathologic findings in the few cases that have been studied post-mortem.

An outstanding and most disturbing symptom has given the name to the condition and partly accounts for much of the confusion existing in its discussion and literature and has hindered accurate description and uniform understanding of this most distressing ailment. Even before any pathologic changes had been demonstrated by post-mortem studies, two theories as to

the etiology were extant, namely, the psychogenic or as it is sometimes termed, the functional; and the organic, in which structural changes were predicated in the central nerve system. These classifications still obtain despite the disparity between the clinical evidences of two patently differing conditions.

The first, or psychogenic, theory postulates abnormal emotional reactions in a patient or subject of distinctly neurotic type in whom, as a consequence of some mental or physical (or both) stress or fatigue, muscle spasms occur. The inherent instability of the system (either congenital or acquired) renders the nerve cells in the base of the brain (which supply the eleventh cranial and the first and second cervical nerves) more susceptible to the external stimuli of occupation or surroundings, and result in their hyperactivity. In other words, it is a basically functional weakness of the nerve cells, which, under severe mental or physical stress gradually produces a chronic spasm of the muscles motivated by them. In the development of this theory, it is highly probable that the cells are in a state of debility or exhaustion from overuse which renders them more susceptible to irritative and stimulating external conditions, but which is not followed by *degenerative* or *pathologic changes in the cells*.

The second, or organic, theory predicates a pathologic lesion in the basal ganglia of the brain, including the striatum, the capsule, the basal nuclei or "a disturbed labyrinthine function due to a unilateral lesion of the brain stem" (Grinker<sup>1</sup>). Grinker also believes that the condition involves the capsule and at times the adjacent nuclei. Post-mortem examination in several cases has shown pathologic

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changes in the "large cells of the caudate and putamen" (Alpers and Drayer<sup>2</sup>).

The writer believes it entirely conceiv-

relieved by prolonged fixation, without any relation to underlying pathology but purely with the idea of giving relief from the pain



FIG. 2. First celluloid brace.



FIG. 3. Second brace.



FIG. 4. End result.

able that the long-standing and persistent cases of the psychogenic type of pure and uncomplicated spasm *might* develop secondary degenerative changes in the central motivating cells but thus far there have been no published results of post-mortem findings in such cases and no clinical evidences of central pathologic complications in this type. In two of the cases treated, the spasm had been present for eight or more years yet there was no evidence of muscle or fibrous tissue changes and complete relief was obtained by the method of treatment to be described. The position of the head in all of these cases is analogous to that of the ischemic or traumatic wry neck commonly seen in childhood and following injury to the sternocleidomastoid muscle, but differs in that (1) the spastic type presents no structural shortening of the muscles or infiltration of the intramuscular fasciae such as is always present in the traumatic type, and (2) the contraction is clonic and not constant.

From the series of cases treated, the writer believes there are two distinct types of the affection and that both theories are correct, each in its respective type. Several of our earlier patients were completely

and spasm. However, the results of the treatment and more intensive study of the symptoms of the cases evidenced a marked clinical difference between the two types and also suggested the probable cause of the failures following surgical and other methods of treatment. The differentiation of the two types is made from the character of the symptoms present. In the pure or psychogenic type of case, there are no other symptoms than the clonic spasm of muscles, singly or in groups, while the organic type presents symptoms referable to degenerative changes in the motor cells. These changes are characterized by athetoid movements in various parts of the head and neck. Thus, it was felt that, in the psychogenic cases, there was probably some local functional disturbance rather than a degenerative condition in the motivating cells. This distinction has been the criterion in the selection and treatment of our cases. In several of our patients, the spasm had persisted for six or more years, but no other symptoms have developed. In the organic type, however, the athetotic movements developed early with the torticollis spasm and gradually involved various parts of the upper body such as the tongue, neck, arms and hands and in these cases



it was felt that failure would follow the measures which proved successful in the others. We believe there a sharp distinc-

the stress of life, occupation or environment, developed an asthenia or exhaustion of the basic cells which in turn rendered



FIG. 5. Another type of brace to follow cast.

tion must be drawn between the two types and that the so-called psychogenic should be known as the true spasmodic torticollis while those cases which present other symptoms characteristic of degenerative changes in the basal ganglia and cells or in other parts of the base of the brain, should be classified by a title descriptive of the pathology in those parts.

Another strong argument in favor of this distinction lies in the results of the treatment. Heretofore, the common name of spasmodic torticollis carried with it a hopeless outlook for relief. Most writers claim that all methods of treatment, whether mechanical, electrical, surgical or physiotherapeutic, were failures or left the patient almost as badly crippled as before (this is especially evident after neurectomies). It is highly probable that where failure resulted, it was due to a lack of differentiation between these two outstanding types of cases. Stimulated by the failures of surgical and other measures and impressed by the theory of psychogenesis as exemplified in other conditions, we were led to feel that we were dealing with a badly balanced nerve system, which under



FIG. 6. End result in 46 year old patient with most resistant type.

them hypersensitive to external stimuli thus reflexly setting up spasms in the muscles motivated by them.

In 1863, Hilton (London) published his lectures on "Rest and Pain," a book which remains a classic to the present day and provides a basis for the successful treatment of many more recently recognized ailments. He demonstrated that the mechanical and physiologic rest of parts, which are or have been subjected to injury or strain, was one of the most potent factors in the restoration of health to those parts. Acting upon the principle that the central cells and the muscles motivated by them complement each other, we decided to try placing the central cells at rest through immobilization of the parts which they supply. This principle of treatment is not new. It had been tried in this condition many years ago but was discarded as unsuccessful. We believe that the reason for failure in these attempts was either a lack of persistence on the part of the physician and patient in carrying out the plan of treatment or failure to recognize the dif-

ference in the two types of torticollis. More rapid methods of relief or cure have also been tried, but they too have failed utterly

sary to cut out part of the cast. However, she persisted with the treatment and after two and one-half years of fixation, was



FIG. 7. Before treatment.



FIG. 8. Two and one-half years after treatment had been started.

or have left the patient with a loss of head and neck control fully as dire as the original malady.

Profiting by the markedly beneficial results of the complete physiological rest to the nerve cells in cases of completely or partially paralyzed muscles in infantile paralysis, through the removal of all stimuli from those cells by external fixation of the motivated parts, we felt that if the head and neck muscles could be securely and firmly fixed by plaster of Paris for a sufficient length of time, the basal cells supplying them would be placed at rest. With an opportunity to recover their tone, the cells would lose their hyper-tonicity.

The coöperation of patients over varying periods of time has allowed us to use the method. Results have proved the correctness of the theory. In one patient, a woman 47 years of age, the spasm of the muscles was so great that an anesthetic was necessary for holding the head straight while the cast was being applied. This patient developed a pressure sore on the cheek within three days, making it neces-

relieved of all spasm and remains well today (after twelve years).

For the application of the cast, the patient is preferably seated on a stool, the hair is cut short and stockinette is slipped over the head and well down on the chest, holes being cut for the arms. Cotton wadding is then placed about the body, neck and head. An assistant holds the head in as correct position as possible, the arms are held extended laterally at a right angle and plaster bandages are wound snugly about the body, neck and head. Reinforcing slabs are placed from the top of the head down the back and pressed closely to the neck. The bandage covers the entire head, but leaves the face open. When the plaster has set firmly, the cast is trimmed about the face and about the lower edge of the jaw, allowing a slight space for jaw action. The ears are then uncovered and the armholes carefully trimmed. This cast is worn for at least six months and sometimes a year. In hot weather, it should be changed every six months, great care being used to preserve the corrected posture. The comfort following the arrest

of the spasms insures coöperation of the patient in spite of the discomfort of the weight of the cast and the odors from

asmuch as there still remained three or four years for growth and development and as the influences of these processes often



FIG. 9. Celluloid and metal splint following plaster of Paris.



FIG. 10. End result after three years of treatment.

the skin. After about two years, when the third or fourth cast is removed, the patient is able to hold the head quite still and there is seldom any pull of muscle except in the presence of excitement. A celluloid cast is then made over a plaster mould and so cut that it can be removed for bathing. This must be worn continuously for four or five months and can then be gradually removed for the application of a light steel support which provides a sense of fixation rather than its reality. Within a few months more, this is gradually laid aside. In excitement or unusual fatigue, these patients may have a slight sense of tension, but this quickly disappears and in none of our ten cases has there been a recurrence.

In one case, a boy of 13, suffering from mild congenital spastic diplegia involving the entire body, there was distinct torticollis and associated athetosis of the head, neck and arm muscles. His activities were greatly impaired and the uncertainty of his movements prevented him from joining in the sports of his playmates. In-

exert a most beneficial effect upon the spastic condition, it was decided to try the fixation treatment. Plaster of Paris was used (about the head and shoulders) for two years and this was followed by a removable celluloid and metal brace. The results have been beyond our expectations. The patient has gained greatly increased control of his head and arms. Now when the brace is removed, he is able to control these parts much better and they show much less spasticity than previously. In addition, the boy's mental reaction to his surroundings has been greatly improved and he is rapidly losing the inferiority complex that formerly handicapped him. He plays ball and has even joined in football with his schoolmates. Although there is evidence of steady improvement, it is not to be expected that the congenital brain changes will be completely overcome. The prolonged rest has, however, been of great value and there is every reason to feel that further growth will promote greater improvement in his condition.

## SUMMARY AND CONCLUSION

This presentation offers three main points regarding spasmodic torticollis: (1) the careful differentiation between two patently separate conditions which present one outstanding symptom in common; (2) the need for efficient and prolonged fixation, preferably by plaster of Paris, until

spasm is overcome; (3) the necessity of absolute coöperation on the part of the patient in following out the treatment.

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THE reflex of the tensor fasciae latae is unaffected in sciatic neuritis, but is usually lost in affections of the lumbosacral roots.

From—"The Injured Back and Its Treatment" by Ellis (Charles C. Thomas).

# SURGERY IN SYPHILITIC WOMEN\*

ALBERT PHILIP, M.D., F.A.C.S.

NEW YORK CITY

**S**YPHILIS in its relation to surgery brings up problems which need investigation. Textbooks on surgery mention these problems meagerly, and the literature fails to give comprehensive material for clarification. The problems with which the surgeon is confronted are as follows:

1. Differential diagnosis.
2. Prognosis:
  - (a) Surgical risk.
  - (b) Prevention of surgical complications.
  - (c) Prevention of infection of the part of the surgeon.
  - (d) Comparison of recovery and wound healing between syphilitic and non-syphilitic patients.

It frequently happens that through errors in diagnosis, patients with syphilitic manifestations are subjected to unnecessary operation. The gastric crisis of tabes dorsalis may mimic a surgical abdomen. Muzum collected a long list of needless operations of this kind. Fabian reported a case in which what seemed to be metastases, appeared below the left costal arch five years after an ovarian tumor had been removed. A Wassermann taken was positive, and, after anti-syphilitic treatment, the growths disappeared. These tumors and the original ovarian tumor were gummata. Gellhorn cites a case where at operation he thought he was dealing with an inoperable carcinoma of the liver; anti-syphilitic treatments cured the patient. In many instances chancres or gummas of the cervix have been mistaken for carcinoma.

Uterine hemorrhages may be caused by syphilitic changes in the uterus.

Plastic peritonitis may be due to chronic syphilis, and many operations for adhe-

sions, chronic appendicitis, and diseased pelvic organs are performed without a final cure resulting.

Stein and Hensel reported a case in which operation was done with the preoperative diagnosis of a large intra-abdominal tumor, ovarian cyst or pedunculated fibromyoma, or mesenteric cyst. Before operation the blood Wassermann was negative. At laparotomy the abdominal cavity was empty. The tumor was a suppurating large gumma of the abdominal wall. The spinal fluid Wassermann was positive after the operation; abnormal reflexes pointed to tabes dorsalis. With thorough anti-syphilitic treatment the tumor disappeared in about two months.

Recasens writes of a case of syphilitic endometritis, a rare occurrence, in which he had operated upon by error, performing a vaginal hysterectomy.

All these examples show how important it is to make a differential diagnosis before operation. At the House of Detention for Women of the City of New York, a Wassermann and a check test are performed routinely. Because these procedures are not always followed in private institutions, such mistakes as listed above may occur. Wassermann or other tests, spinal fluid examination, dark field and histologic examinations will decrease surgical errors. A trial of anti-syphilitic treatment in suspicious cases is a wise procedure even when Wassermann and all other tests are negative. Keen judgment helps to prevent surgical errors.

As to the question of *prognosis and surgical risk*, differentiation must be made between unrecognized, untreated cases of syphilis, and treated cases. In the first group the prognosis must be considered theoretically poor. It is recognized that spi-

\* From the House of Detention for Women of the City of New York, Department of Correction Hospitals; Director of Surgery, Edward C. Brenner, M.D., F.A.C.S.

rochetes spread through blood and lymph vessels very rapidly and cause a general systemic infection. Almost every part of the body is affected, especially the circulatory system, heart and aorta. The kidneys and brain frequently remain damaged even after treatment. A syphilitic cachexia may develop—especially in young women. Insurance companies rate individuals who have had syphilis in the second class.

Many postoperative complications due to syphilis are described in the literature. In one, after a fibroid uterus had been removed, the wound did not heal and the diagnosis was not made until a gumma developed. Specific ulcerations and extensive suppurations may develop in a wound or incisions may open up without suppuration. All these wound complications may readily react to specific treatment. However, operative mortality from cerebral hemorrhage of syphilitic origin may rise. General anesthesia might conceivably affect brain pathology, while spinal anesthesia is rejected by some surgeons because of the possibility of exciting an old syphilitic meningitis.

Prognosis and surgical risk are much better in old treated cases of syphilis than in untreated cases, as our statistics show. At least two weeks preoperative treatment should be instituted. In acute surgical cases, if there is no time for such treatment, it should be given during convalescence. Patients with old syphilitic organic lesions, with severe anemia or cachexia, etc., are poor risks, and operation should, if possible, be deferred.

Brief mention should also be made of the possibilities of infection during operation. The physician, his assistant, or an infected instrument may occasionally be the cause of inoculating a patient with lues. The surgeon can also inoculate himself after some injury, perhaps so slight that nothing is noticed until secondary lesions appear. Untreated patients may infect the surgeon, but it is probable that even small amounts of anti-luetic treatment will render the disease non-infectious.

The material here presented is drawn from a penal institution. From 1933 to 1938 inclusive, there were 775 operations in the House of Detention for Women of the City of New York. The greater number were minor operations which are eliminated. We have selected for comparative study the more important major operations, numbering 164. The ages of the patients ranged between 20 and 62, but most were in their thirties.

All patients had a venereal check-up in which at least two types of laboratory tests for syphilis were performed. All syphilitic patients received preoperative treatment consisting of at least six neosalvarsan and ten bismuth injections. Women with untreated syphilis were not operated upon, except in emergencies. Anti-syphilitic treatment was resumed in all cases during convalescence.

In these 164 cases there were eighty-three instances of old syphilis treated preoperatively, and eighty-one with no evidence of the disease.

The diagnoses among these 164 patients were:

Adnexal conditions.....	56
Fibromyoma of uterus.....	48*
Large cystoectocle and lacerated cervix.....	13
Ovarian cysts.....	7
Retroversion.....	3
Rectovaginal fistula.....	1
Tubal pregnancy.....	1
Prolapse of uterus.....	1
Torsion of uterus causing acute surgical abdomen.....	1
Gall-bladder conditions.....	9
Thyroid conditions.....	6
Hernia.....	3
Carcinoma of breast.....	1
Acute appendicitis.....	4
Acute intestinal obstruction.....	2
Kidney conditions.....	2
Eye conditions.....	4
Ear condition.....	1
Orthopedic condition.....	1

\* About 50 per cent were complicated by adnexal or other conditions.

The types of operation performed were:

Hysterectomy	
Supracervical.....	43
Total.....	2
Conservative pelvic operation.....	71

Vaginal and cervical repair . . . . .	13
Cholecystectomy . . . . .	9
Cholecystostomy . . . . .	1
Thyroid operation (usually subtotal thyroidectomy) . . . . .	6
Exploratory laparotomy . . . . .	2
Hernia repair . . . . .	4
Appendectomy . . . . .	4
Radical mastectomy . . . . .	1
Enucleation of eye . . . . .	4
Nephrectomy . . . . .	1
Nephrostomy . . . . .	1
Major orthopedic operation . . . . .	1
Mastoidectomy . . . . .	1

The operations were carried out under general anesthesia in most cases, but spinal was used in a few selected instances.

To evaluate the results of operation, we considered the mortality, the morbidity, and the wound healing as criteria, and we compared the infected with the non-infected groups.

We had three deaths in this series of 164 operations (1.82 per cent). Two had syphilis, one did not.

The morbidity may be a better criterion for comparison. Twenty-one patients had a disturbed postoperative convalescence, a percentage of 12.80 per cent. Of these there were thirteen old syphilitics and eight non-syphilitics. There was a slightly greater percentage of postoperative complications in infected than in non-infected women.

If wound healing is taken as a criterion of the operative results, the following data are pertinent:

	No.	Per Cent
Primary union . . . . .	140	85.37
Old syphilitics . . . . .	65	
Non-syphilitics . . . . .	75	
Wound infection . . . . .	24	14.63
Old syphilitics . . . . .	16	
Non-syphilitics . . . . .	8	

Most of the wound infections were slight. We also included among these wound infections, cases with original drainage during operation, healed by secondary union. Wound healing was apparently better in non-syphilitic cases, but in our series we could not attribute any wound infection to gumma or syphilitic ulceration.

It should be noted that among the operated cases, there were more than 50 per

cent with a history of gonorrhea and about 15 per cent were drug addicts. These conditions might well influence the operative prognosis.

TABLE I

Wound Healing	Total		Syphilitics 83		Non-syphilitics 81	
	No.	Per Cent	No.	Per Cent	No.	Per Cent
Primary union . . . . .	140	85.37	65	78.43	75	82.58
Wound infection . . . . .	24	14.63	16	19.27	8	9.07
Postoperative morbidity . . . . .	21	12.80	13	15.66	8	9.07
Mortality . . . . .	3	1.82	2	2.40	1	1.23

The three deaths which occurred are briefly reported:

I. M. A., age 36, white, was admitted to the surgical ward with an acute exacerbation of a pelvic inflammatory disease. She had a high temperature and a leucocytosis of 18,000. She was in the hospital under conservative treatment for three weeks. Blood Wassermann was negative. During this time, the abscess ruptured and drained through the rectum. Not much improvement occurred and the patient was desirous of operative relief. Bilateral salpingo-oophorectomy was performed. Postoperatively, the patient's condition was poor, and in spite of supportive treatment, she died in sixteen hours, possibly from shock. Post-mortem examination was refused.

II. O. T., age 38, colored, was admitted to the surgical ward with a diagnosis of possible intestinal obstruction. The patient had an old syphilis, untreated in the institution. She was operated on October 14, 1936. Exploratory laparotomy and ileostomy were performed. She died the next day.

At autopsy there was dark reddish fluid, especially in the pelvis and in both flanks. The intestines were distended, partly reddish brown in color. Circumscribed peritonitis was present above pelvis.

Both lungs were adherent to the posterior pleural wall. The descending aorta showed beginning sclerosis in the form of yellowish patches. Adhesions were noted between the diaphragm and right lobe of the liver.

The loops of the ileum were situated in the pelvis and a small hole 1 inch in diameter was found in the mesosigmoid. Into this hole protruded several twisted loops of ileum. The margins were firm and showed no signs of fresh laceration. The mesenteric vessels did not show thrombosis.

The cause of death had been intestinal obstruction from abdominal hernia through a congenital defect in the mesosigmoid.

The above two deaths were surgical deaths. Apparently syphilis played no part in the final outcome.

III. E. S., age 45, white, was admitted to the hospital with the diagnosis of ovarian cyst, chronic cholecystitis, and cholelithiasis, vascular syphilis, chronic drug addiction, and chronic gonorrhea.

Her syphilis dated back to 1927. She had had four courses of anti-syphilitic treatment in 1936 and before operation she had a few salvarsan and a few bismuth injections. She had been a drug addict for fifteen years.

On June 16, 1938, left oöphorectomy and cholecystectomy were done under general anesthesia.

During convalescence, the following complications developed: bronchopneumonia; multiple abscesses in the left lung; empyema of chest. She was operated on again on September 3, 1938, when a left pneumonostomy was performed. Blood transfusion was given after this operation. The patient died on September 14, 1938 with signs of a pulmonary embolus.

**Autopsy.** In the right upper lobe, there was an abscess 1½ inches in diameter, with congestion and edema in this lung. In the left chest there was 600 c.c. of pus, and many abscesses in the left lung. The aortic walls were thickened at the bases of the cusps. The coronary arteries were slightly sclerosed. The descending aorta showed many linear "tree barked" areas, pearly gray in color and there was slight thickening of the aorta itself with scattered, raised, yellowish, atheromatous plaques. The liver was congested with parenchymatous degeneration. The spleen was larger than normal. The kidney surfaces showed two large scars. The cortex and medulla were diminished, and several cysts were found in the parenchyma. The brain showed marked atrophy of the cerebral gyrae, and the gray matter was atrophic.

In this patient there was evident marked pathology of the organs as a result of the old syphilis. She had to be considered as a bad operative risk and probably the complications could be attributed to these pathologic changes. She had also been weakened by her drug addiction.

#### DISCUSSION

One hundred and sixty four major operations were studied. In each case at least two laboratory tests for syphilis had been done. With the exception of emergencies, every syphilitic patient was treated routinely before operation. There were no cases of acute syphilis in this series. The operative results were studied in two groups and compared on the basis of mortality, morbidity, and wound healing.

It is the consensus of opinion of the medical profession that patients with acute syphilis should not be operated, except in grave emergencies. This precaution is for the safety of both the patient and the surgeon.

By a routine Wassermann test many questionable diagnoses may be clarified and postoperative results are safeguarded. In addition, the surgeon will be protected against infecting himself on an unrecognized syphilitic patient. Cases of chronic lues should be given routine treatment.

#### CONCLUSIONS

Serologic tests for syphilis and the institution of anti-luetic treatment when indicated are advisable in all operative cases.

It would appear from this study that chronic syphilis as a complication to surgery presents only a slight risk as regards mortality, morbidity, and wound infection.

It is felt that major surgery in syphilitic patients can be done with comparative safety if the above mentioned precautions are followed.

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IN cardiovascular-renal disease in old people, dietetic and general hygienic regimes should be even stricter and more closely supervised than in younger persons. In time such patients will succumb to myocardial insufficiency, coronary thrombosis, cerebral insults, or uremia, even when the greatest care has been exercised.

From—"Convalescent Care" (New York Academy of Medicine).

# CASE REPORTS

## GAS BACILLUS INFECTION OF THE ABDOMINAL WALL IN APPENDICITIS\*

FRANK J. BRESLIN, M.D., F.A.C.S.

LOS ANGELES, CALIFORNIA

**I**NFECTIONS of surgical wounds by anaerobic gas-forming bacteria are comparatively rare. Infections of this type may occur after any intra-abdominal surgical procedure, but they are most often seen after operations for the relief of intestinal obstruction and of suppurative appendicitis.

Winter<sup>1</sup> was the first man to report what he termed emphysema of the abdominal wall as a complication after laparotomy. He described two cases in 1889.

In 1897, Russell<sup>2</sup> reported two cases which developed on the gynecological service at the Johns Hopkin Hospital.

Simonds<sup>3</sup> in 1915, while working at the Rockefeller Institute, found the *Bacillus welchii*, in a sporulating form, in the pus of most appendiceal abscesses, but he also found these organisms to be present in 90 per cent of normal appendices removed during routine autopsies.

Johnson<sup>4</sup> in 1936, stated that Millar, in 1932, had found but forty-eight reported cases of gas gangrene of the abdominal wall in the literature. To these, he added six additional cases, two being reported from his own work.

It is now a well known fact that the pathogenic anaerobes, together with the colon bacilli, are normally present in the intestinal tract of man. It is not altogether surprising, therefore, that one does encounter an occasional case of gas gangrene of the abdominal wall after surgical procedures attacking the appendix, small intestine and colon. It is surprising that this complication does not develop more often.

The manifestations of this devastating clinical complication which strikes with such vehemence, may well be reported in order that the practicing surgeon may ever be on the alert.

### CASE REPORT

A moderately obese white female, 32 years of age, developed acute appendicitis while visiting in a near-by city. When she was seen, one week after the initial attack, the diagnosis was confirmed. She was subjected to surgery one week later, having been free from fever for eight days.

The surgical findings were a subacutely inflamed appendix of the retrocecal type. The cecum presented mild edema and a moderate degree of induration. It was necessary to amputate the appendix at its cecal end first, and liberate the embedded appendix by sharp dissection. The cecal wall was folded over with mattress sutures in an attempt to reinforce the area of perforation in the cecum near the point where the appendix had been removed. Vestiges of a pericecal abscess were found and a Penrose drain was placed in this region.

The pathologic diagnosis was healing acute appendicitis. There are thick fibrous callous areas in the subserosa, which showed focal areas of active suppuration.

The postoperative course was typical of a gas gangrene complication. The temperature was normal before operation; twelve hours later it had risen to 103 degrees and the pulse was 130. Twenty-four hours after operation, the temperature registered 104 and the pulse was 136. Thirty-six hours after surgery, the patient became quite jaundiced, the pulse was 140 and she was profoundly toxic. Inspection of the abdomen showed moderate distention and there was a slight amount of brownish drainage with a mouse-like odor. The skin of the abdomen was

\* From the Surgical Service, St. Vincent's Hospital, Los Angeles.

bronze in color. Smears and cultures showed the Welch bacillus. Two doses of anti-gas gangrene serum were given, but the patient expired fifty-hours after operation.

Upon incising the deep layer of the subcutaneous tissues over the right rectus muscle at post-mortem, a vesicular tissue was encountered from which a considerable quantity of a gray, opaque fluid escaped. There were definite globules of fat floating in the fluid and the tissue was crepitant with definite gas bubbles apparent. The anterior surface of the left rectus fascia, in about the mid-part, was entirely defective. The muscle tissue had a gray color, a boiled appearance, a friable consistency. There was definite liquefaction and dissolution of its substance. The same change was noted in the right rectus muscle, with the site of maximum involvement extending along the surgical incision. The change bilaterally ended rather abruptly at the level of the upper transverse tendinous inscription. The process extended laterally into the fibers of the transversalis and internal oblique. This was most marked on the left. The subcutaneous tissues under the discoloration of the skin of the left abdomen were especially indurated, showing diffuse cellulitis. The inflammatory process extended inferiorly in the abdominal wall to the pubis, involving the pyramidalis muscles as well as the recti. The tissues of the labia were swollen and indurated and contained an abundance of fluid.

Microscopic sections of both the right and the left rectus muscles showed a diffuse acute phlegmonous process. The interstitial tissue had been invaded by the exudative product of acute inflammation, and this, together with gas produced by micro-organisms, had tended to separate the individual muscle cells and caused necrosis of large numbers of them. The necrotic cells showed a fragmentation and clumping of the sarcoplasm and polymorphonuclears were visible within many of these muscle fibers. Elsewhere were large areas in which the cellular outlines had been completely lost. At the periphery, the cells were swollen and showed earlier evidences of degeneration. The picture was one of extremely acute cellulitis in the early stages of development. There still remained areas in which myriads of Gram-positive micro-organisms, mostly bacilli, were visible. Several of the smaller blood vessels within the limits of the acute process had been completely thrombosed.

## SUMMARY AND CONCLUSIONS

This case presents a rare and fatal complication following appendectomy. Following several attacks of pain in the abdomen, considered to be due to appendicitis, an acutely inflamed appendix was removed and the stump was inverted and reinforced with mattress sutures. It was noted at the time of the operation, that the immediately adjacent area of the cecum and the base of the appendix were considerably edematous and indurated. Almost immediately following the operation, a marked reaction was observed, characterized by a high fever, restlessness and pain in the right labium and in the left side of the abdominal wall. On the third postoperative day, the patient died.

Necropsy revealed an acute, generalized peritonitis and a very extensive gas bacillus infection of the abdominal wall. Apparently the source of the infection was the appendiceal stump, for in this area, a pericecal abscess was found and the tissues of the inverted stump were necrotic.

Two points of rather unusual interest in this case are, first, the fact that the infection of the right rectus muscle was limited in its extension upward by one of the tendinous inscriptions, and secondly, it is curious how the infection could spread from the right rectus across the barrier of the linea alba to involve the left rectus muscle and the left abdominal wall. It is only speculative, but probable, that the infection followed a route via the pyramidalis muscle.

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# SARCOMA OF THE STOMACH

DONALD E. ROSS, M.D., F.R.C.S. (ENG. AND ED.), F.A.C.S.

Ross-Loos Medical Group

LOS ANGELES, CALIFORNIA

**S**URGICAL literature has numerous case reports and, indeed, fairly lengthy series of sarcomata of the stomach. In

cinoma and sarcoma grossly and even microscopically. Cases of carcinoma with metastasis have exhibited cells which re-

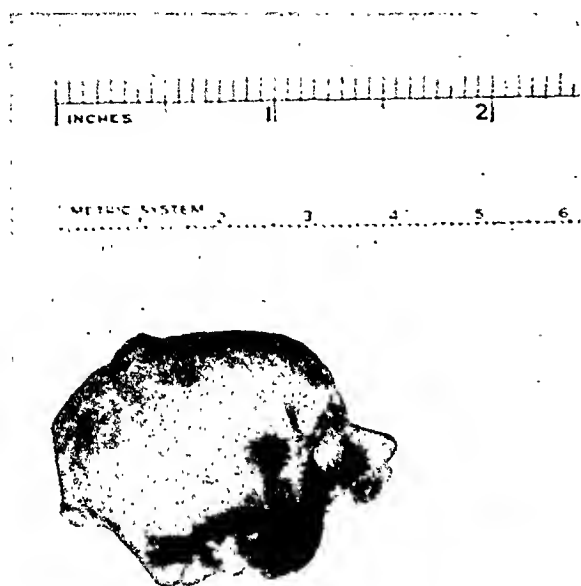


FIG. 1. Illustration of gross specimen. Note the round, dark, ulcerated area which has the appearance of a dimple, and which held the fleck of barium suggestive of sarcoma.

spite of this, gastric sarcoma must be considered very rare. It is also very infrequently diagnosed preoperatively. It is of the greatest importance to make such a diagnosis, since a fairly large sarcoma may still be operable, and those which are not may be materially improved by x-ray therapy. Diagnosis is, therefore, of the utmost value. While this is very difficult in many cases, it may be accomplished frequently by giving attention to certain details. The author wishes to report a case diagnosed before surgery; also some points relative to the differential diagnosis are discussed.

**Pathology.** About 1 per cent of tumors of the stomach are sarcomas. There is considerable confusion in classification since many are mixed celled varieties. There may be difficulty in differentiating between car-

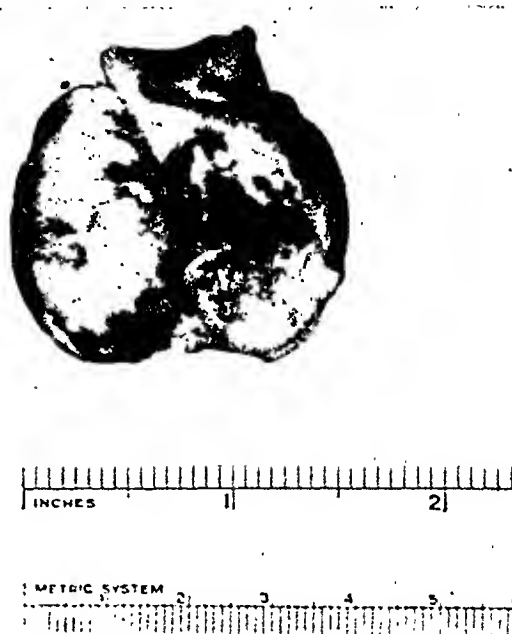


FIG. 2. Gross specimen divided. Note its mottled appearance.

semble sarcoma and have been reported as a mixture of the two. It is believed that any definitely malignant ulcer should be regarded as carcinoma.

**Ewing Classification.** (1) spindle cell myosarcoma; (2) lymphosarcoma; (3) miscellaneous round cell or alveolar sarcoma.

Spindle cell myosarcomas form solid tumors which may protrude into the stomach or extragastrically; they may remain interstitial; often ulceration occurs; they may grow to tremendous size. Brodowsky's tumor grew to the size of a child's head. In Cantwell's case it weighed 12 pounds, while Baldy's nearly filled the abdomen. Most of these tumors arise from the curvatures.

Lymphomatous tumors occur: (a) as part of the leucemic process; (b) in gastrointestinal leucemia; (c) as part of a general lymphosarcoma; (d) localized lymphosarcoma.

## Ross—Sarcoma of Stomach

Miscellaneous types. Gross forms assumed by sarcoma vary greatly. The spindle-celled or mixed variety may form a

barium mixture is advisable. Also the partly filled stomach may yield better results. One must note particularly the ru-



FIG. 3. Sarcoma of the stomach. Note the persistent fleck of barium filling the ulcerated area of the sarcoma.

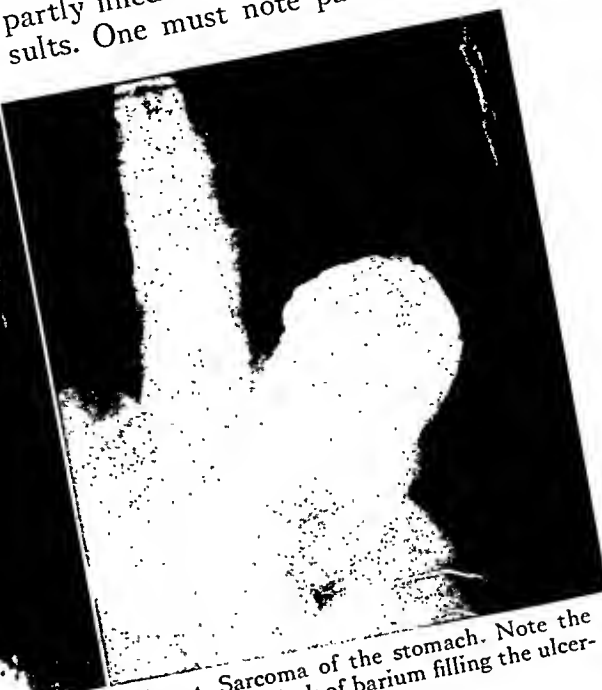


FIG. 4. Sarcoma of the stomach. Note the persistent fleck of barium filling the ulcerated area of the sarcoma.

ball-shaped endogastric mass which has the appearance grossly of a benign tumor. However, if there is an ulcerated area in the center which can be seen as a "button filled with barium" on roentgenologic examination, then it marks it more definitely as a sarcoma. The stomach has normal rugae up to the base, and frequently the mucosa is flattened out over the mass.

Sarcoma also frequently extends extra-gastrically, and may form a dumbbell (as shown by x-ray) when ulceration occurs.

Lymphosarcoma begins usually in the submucosa, and may extend widely.

**Differential Diagnosis.** A careful history is necessary. Bleeding is frequent and often pain is excessive. The patient may be quite well nourished.

A massive tumor leads one to suspect sarcoma. Also, as in the author's case, a deformity which has an ulcerated spot in the center, filled with barium, makes a diagnosis relatively positive.

X-ray is probably the best clinical adjunct. In this connection, the use of a thin

gastric, the flexibility of the walls and the peristalsis.

The writer wishes to refer to an article by R. A. Carter and R. Laing, in which this phase of the subject is admirably covered.

The following entities are normally considered: (1) benign growths; (2) benign ulcers; (3) carcinomata; (4) syphilis; (5) lymphoblastic sarcomata; (6) mixed-celled and spindle-celled sarcoma.

Benign tumors are more common than was thought. The incidence now is considered to be from 11 to 17 per cent. They present the following characteristics: (a) usually multiple; (b) 69 per cent are near the pylorus; (c) frequently pedunculated; (d) may form a cluster and be so close together that thick barium may not penetrate to the base—therefore best examined with thin barium with a partially filled stomach; (e) anacidity may be present; (f) hemorrhage may occur in varying degree; (g) symptoms, usually vague, but may be acute should prolapse occur through the pylorus; (h) rugae are normal up to the

tumor; (i) no contracture of the stomach occurs; (j) peristalsis normal; (k) usually are much smaller than the larger rounded endogastric masses of fibrosarcoma, which

2. Age incidence—average age in carcinoma is 61, in sarcoma, 40.

3. Sex—sarcoma is much more frequent in males (70 per cent) than in females.



FIG. 5. X-ray of the same stomach showing the stomach well filled with barium. This does not permit the showing of the outline of the tumor, and particularly the ulcerated area on the tumor. It is, therefore, necessary to take several x-ray pictures.

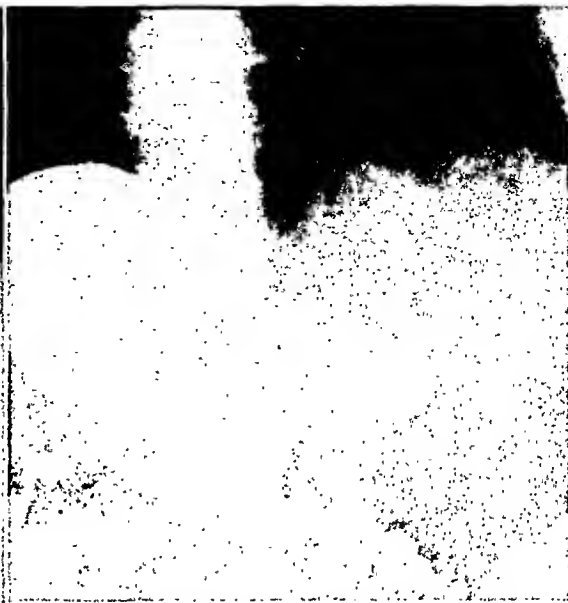


FIG. 6. Cancer of the stomach. (Of interest for differential diagnosis.)

do not exhibit the barium filled "button"; (l) usually occupy the anterior or posterior wall, leaving the curvatures free and do not interfere with peristalsis.

*Benign ulcers* have a history of dyspepsia and hyperacidity with pain which usually has a definite relationship to food. X-ray examination shows deformity, ulceration, and interference with peristalsis; often hypermotility and frequently six-hour retention and spasm.

Where a definite large, flat ulcer occurs, one must rule out sarcoma, and then differentiate between benign ulcer and carcinoma.

*Carcinoma.* Sarcomas are usually diagnosed as carcinoma since the symptoms are very similar. They have in common, dyspepsia, anorexia, loss of weight, anacidity, and occult blood. However, the following points may be of value in differentiation:

1. Rapidity of growth—greater in carcinoma. Sarcoma may take several years to mature.

4. Pain—may be absent in carcinoma and is frequently severe in sarcoma.

5. Gastric hemorrhage is more likely in sarcoma, although occult blood is present in both.

6. Size—the occasional "bulk" of sarcoma may give a suspicion of its character.

7. Any large ulcer should be regarded as carcinoma rather than sarcoma. (Confusion has occurred where mixed types were reported but metastases were carcinoma.)

8. Loss of weight—more frequently occurs in carcinoma. Some stress the well preserved condition of the patient.

9. The presence of a rounded tumor with a barium filled "button" is very diagnostic of sarcoma.

*Syphilis.* Here there is usually no mass which one can feel by palpation, and the patient's general condition is usually much better than one would expect from the extent of the lesion in the stomach. Serologic examination may also give a clue.

X-ray examination shows: (a) lessened flexibility and motility; (b) lumen of the stomach may be contracted; (c) absence of peristalsis may be marked; (d) pylorus

tends to gap; (e) smooth annular constriction sometimes occurs.

*Prognosis in Sarcoma.* Balfour states



FIG. 7. The above is an x-ray of large multiple ulcers of the stomach. (Of interest for differential diagnosis.)

that of fifty-four cases, thirty-eight were operable. Of this series, two were diagnosed as sarcoma previous to operation. Twelve were alive, the average postoperative period being five years.

*Operation.* The most logical operation is a wide, partial gastrectomy. However, in certain selected cases, the less radical local resections may be all that is necessary. Rancohoff and Dickson believe this to be true.

#### CASE REPORT

Male, age 52, weight 140, height 5 feet 6 inches. Occupation: mail clerk.

The patient had had no serious illness. A hernia had been treated successfully by the injection method.

He had been entirely well until a year before when he began having obscure aches and pains in the abdomen. These were not serious in character, and he did not present himself for diagnosis until he suffered a severe hemorrhage and was sent to the hospital. A blood transfusion was given. Having recovered, the patient was x-rayed, and the presence of a large, smoothly rounded filling defect, occupying the

middle third of the stomach, exhibiting a central fleck of barium was reported. The lesion did not appear to be invading the stomach wall, and did not move or change position.

A recheck examination two days later reaffirmed the findings. A diagnosis of sarcoma of the stomach was made.

Gastric analysis showed blood 3 plus; total acidity of 60, free acid of 45 and combined acid.

At operation no sign of any local extension was seen. No glands were involved, and the liver appeared normal. The tumor was about the size of a tangerine, and was very benign in appearance.

The rugae over the tumor had completely disappeared, the mucous membrane being smooth, but the rugae on the stomach were normal up to the edge of the tumor. The mass was freely movable, showing that there was no infiltration into the gastric wall, and there was little extension along the wall. The ulcerated area which had been seen by x-ray marked the mass as a sarcoma. Wide local resection of the tumor was done, and the stomach wall repaired. The patient made an uninterrupted recovery.

*Pathologic Report* (Brem, Zeiler and Ham-mack). The specimen consisted of a piece of gastric wall which measured 6 cm. in greatest length. There was a normal-shaped mass 4.5 by 3 by 3 cm. beneath the mucosal surface and grossly demarcated from it. The overlying mucosa showed a small, oval-shaped, depressed area over the midportion of the mass, 1 cm. in greatest diameter and 0.5 cm. in depth. The mass appeared to be continuous with the underlying muscularis.

Section showed a circumscribed tumor just beneath the submucosa and sharply demarcated from it. The mucosa itself had relatively normal glands with some pressure atrophy, while the tumor was very cellular, highly anaplastic and mesoblastic. There was marked pleomorphism of the cells, many of which were spindle, others polyhedral, still others round. They varied greatly in size, some being relatively small and others quite large giant cells with multinuclei. There was an appreciable amount of inter-cellular stroma. Many of the nuclei were hyperchromatic and there was an equal number of mitotic figures. Alveolar arrangement was missing. A moderate infiltration of the interstitial spaces with round cells and some free blood were noted, the latter possibly of traumatic origin. The blood vessels were relatively

few in number. Pathologic diagnosis was mixed cell sarcoma of the stomach. The patient resumed his occupation six weeks following operation. Five weeks later he had no indigestion, ate a general diet, and had gained 6 pounds in weight. Gastric analysis showed free hydrochloric acid, combined acid, occult blood.

#### SUMMARY

1. A case of sarcoma of the stomach diagnosed preoperatively is reported.

2. The importance of diagnosis is emphasized since failure may lead to the faulty conclusion that an inoperable carcinoma

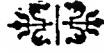
exists. Operation or radiation may thus be withheld.

3. Operability is greater, and the prognosis better, than in carcinoma.

4. Points of differential diagnoses are given.

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# CONGENITAL PYLORIC STENOSIS IN A PREMATURE INFANT FOLLOWED BY GANGRENOUS APPENDICITIS

H. D. VICKERS, M.D. AND J. W. CONRAD, M.D.

LITTLE FALLS, NEW YORK

GALLAGHER of Philadelphia, in 1937, reported the case of a thirty-one day old infant weighing 3 pounds 8 $\frac{3}{4}$  ounces successfully undergoing a Ramstedt operation for pyloric stenosis. The infant was premature, having been delivered by cesarean section from a toxemic negress. Gallagher considered this the smallest baby which had withstood this surgical procedure.

We wish to report a similar case in an infant weighing 3 pounds 12 ounces. Because the baby survived a second major surgical procedure eight months later for the relief of a ruptured, gangrenous appendix, the case is of special interest.

On November 30, 1937, Mrs. A. D. was delivered of a 4 pound male infant under pudendal block anesthesia after spontaneous rupture of the fetal membranes. The gestation period was calculated to be thirty-one weeks (seven and three-fourths lunar months). The mother was unable to nurse the infant and he was given a formula of cow's milk and dextrimaltose. In three weeks he was slightly above his birth weight and was discharged from the hospital.

One week later, a month after birth, the baby was returned to the hospital because of vomiting, loss of weight, and constipation. Although the baby had been vomiting only twenty-four hours, yet its admission weight was only 3 pounds 12 ounces. The baby appeared cyanotic and very dehydrated. Its cry was weak, and only occasionally did it move or kick. All feedings were promptly returned. The general examination was entirely negative. There was no palpable abdominal tumor, nor was peristalsis visible. In view of the history and the lack of physical findings, a diagnosis of congenital pyloric stenosis was made and immediate operation undertaken.

An incision 4 cm. in length was made in the right upper rectus region after infiltration with

1 per cent novocaine. A greatly thickened pyloric muscle was brought into view. It had the typical glistening appearance and extended from the duodenal juncture about 2 cm. into the stomach. The musculature was incised down to the submucosa. No attempt was made to control bleeding. The stomach was replaced and the abdomen closed in layers with fine silk as speedily as possible. The baby was immediately fed small amounts of a cow's milk and dextrimaltose formula which it retained in part. The baby's weight dropped, little by little, until on the sixth postoperative day it was 3 pounds 6 ounces. Semisolid feedings were not used, the baby being kept on the cow's milk formula. However, from the sixth day on the baby made a steady improvement in weight. The wound broke down on the tenth day and complicated the convalescence, but under conservative treatment and adhesive strapping it was completely healed on the thirtieth day. The baby was discharged on the seventieth day weighing 6 pounds 12 ounces.

The infant continued to gain weight at home and remained healthy for a period of five months. On August 27, 1938 the mother consulted a physician because the infant had eaten poorly for the preceding four days and had cried a great deal. Within the next twenty-four hours the baby began to vomit and his temperature rose to 104 degrees. He appeared acutely ill, lying pale and motionless and having shallow, grunty respirations. He cried weakly when moved. The abdomen was distended, rigid, tense, and tympanitic. There was a soft, well defined, tender, lemon-sized mass in the right lower quadrant which could be felt on rectal examination.

The baby was hospitalized immediately. A flat abdominal plate showed distended loops of small bowel suggestive of intestinal obstruction or paralytic ileus. There was a radio-opacity corresponding to the mass in the right lower quadrant. A diagnosis of appendiceal abscess was made. Under 1 per cent novocaine anesthesia, a 4 cm. muscle-splitting incision

was made in the right lower quadrant. About 30 c.c. of foul, thick pus welled out. The appendix was delivered from a position deep in the right pelvis and was swollen, tense, necrotic, and perforated near its base. There was considerable plastic exudate on the cecum and terminal ileum. The appendix was amputated and the stump simply ligated. Five cigarette drains were distributed in the pelvis and right iliac fossa. A few black silk sutures were passed to effect a loose closure.

Postoperatively the infant was given subcutaneous infusions of saline and a transfusion of citrated blood. Drainage from the wound was profuse after the third day. On the thirtieth day the wound was completely and solidly healed and the baby was discharged weighing 12 pounds 2 ounces.

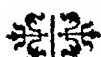
At 15 months of age, the child weighed slightly over 18 pounds.

#### SUMMARY

We report the case of an infant weighing 3 pounds 12 ounces successfully undergoing the Rammstedt operation for congenital pyloric stenosis and later at the age of 8 months recovering from an acute appendicitis with abscess formation.

#### REFERENCE

- GALLAGHER, J. T. F. Congenital stenosis in a 6 months premature infant. *Ann. Surg.*, 106: 299-301 (Aug.) 1937.



# CHRONIC RECURRENT JEJUNOGASTRIC INTUSSUSCEPTION THROUGH A GASTROENTEROSTOMY STOMA\*

GEORGE W. CHAMBERLIN, M.D.

Associate in Radiology, University of Pennsylvania Hospital

PHILADELPHIA, PENNSYLVANIA

**R**ETROGRADE intussusception of the jejunum into the stomach is an uncommon sequel following gastroenterostomy. Steher<sup>1</sup> described a case of this type in 1917 and from that time to June 1937 we have been able to find forty-three similar instances described in the literature.

Two clinical groups have been observed. In one group the patients have a brief illness evidenced by epigastric pain and vomiting, first of food, then of bile, and finally of blood. An epigastric tumor may be palpated above and to the left of the umbilicus. Visible peristalsis and upper abdominal rigidity are often present. The usual preoperative diagnosis have been high intestinal obstruction, a ruptured viscus, or an "acute surgical abdomen." In this group the prognosis is grave and surgical intervention should be immediate.

The other group of patients is composed of those who maintain a state of chronic invalidism following a gastroenterostomy for peptic ulcer. The characteristic symptoms, beginning at any time from five days to fourteen or more years after operation, are epigastric pain, nausea and vomiting, which occur at irregular intervals and subside spontaneously. In these patients, as in the following case report, the radiographic examination aids in establishing the diagnosis.

The patient was a white female of 39, with a long history of recurrent attacks of vomiting following a posterior gastroenterostomy which was done for a duodenal ulcer. The radiographic and gastroscopic examinations diagnosed a recurrent jejuno gastric intussusception.

She was admitted to the service of Dr. Eldridge L. Eliason in March 1936, with a chief complaint of nausea and vomiting for

four days. She had been well until 1919, when she developed a burning pain in the epigastrium. In 1921 an appendectomy was done at another hospital, without relief of her symptoms. In 1926 the epigastric pain and nausea became more severe during gestation, which was terminated prematurely because of nephritis. A second pregnancy resulted in the delivery of a full term child in January 1928. The epigastric pain continued increasing in severity and, in January 1929, a posterior gastroenterostomy was done at another hospital. The patient had an uneventful convalescence but, during the summer of 1929, had a brief spell of vomiting. In March 1936, another attack of vomiting was associated with epigastric pain. Since then she had had recurrent attacks of vomiting. On March 24, 1936, she began to have violent epigastric pain, nausea, vomiting, chills, and headache which lasted, with brief periods of remission, until the time she was admitted to the hospital on March 27, 1936.

The diagnosis on admission was gall-bladder disease. The blood count showed 4,100,000 red blood cells, 77 per cent hemoglobin, 4,700 white blood cells, with a normal differential. The examination of the urine showed nothing abnormal. The Kolmer and Kahn tests were negative. Blood urea nitrogen was 11 mg. per 100 c.c.; blood sugar, 60 mg.; and phenolsulphoncphthalein excretion 35 per cent in the first hour and 20 per cent in the second hour. Gastric analysis showed no free acid.

The fluoroscopic examination of the stomach showed a pliable, partially movable, filling defect, within the lumen of the stomach. (Fig. 1.) This defect showed a constant pattern, consisting of parallel curved lines suggestive of mucous membrane folds of the small intestine. (Fig. 2.) There was delayed gastric emptying and barium leaving the stomach by way of the duodenum reentered the stomach. A diagnosis of intussusception of the small intestine through a gastroenterostomy stoma was made.

\* From the Department of Radiology of the Hospital of the University of Pennsylvania.

On April 3, 1936, a gastroscopic examination by Dr. Gabriel Tucker showed a normal cardia, but the pyloric end of the stomach was ob-

tine. The abdomen was closed and the patient left the hospital on April 30, 1936, after an uneventful convalescence.



FIG. 1. The large filling defect is seen in the pyloric region of the stomach. This film was made with pressure over the stomach.

structed by a mass which projected into the gastric lumen. The mass was covered with mucous membrane and had the appearance of the inside of the bowel. On April 6, 1936, at another gastroscopy what previously had appeared as a rounded mass covered by pink mucous membrane was now a thin, flat fold of the same color.

On April 13, 1936, a laparotomy was performed by Dr. Eliason. When the peritoneum was opened, a number of adhesions were separated from the anterior abdominal wall. The duodenum was adherent to the wall of the gall-bladder and the under-surface of the liver, but no ulcer could be found. The stomach and transverse colon were then lifted up and it was found that a posterior gastroenterostomy of the isoperistaltic type had previously been performed. There was no evidence of a herniation of the jejunum through the gastrojejunostomy stoma. This stoma easily admitted three fingers. There was an adhesion involving the distal loop of the jejunum in such a way that it tended to invert the jejunum into the stomach. This was divided, permitting the jejunum to straighten out. There was no evidence of a polyp or other tumor in the upper small intes-



FIG. 2. Note the appearance after removal of the pressure. The concentric folds produced by the mucous membrane pattern within the stomach are clearly defined.

The patient has been followed in the gastrointestinal department and has had subsequent occasional vomiting attacks. Therapy was given for low plasma protein which seemed to have arrested the vomiting attacks when the patient was last seen in March of 1937.

The evidence is quite conclusive that the patient had a retrograde intussusception of the jejunum which spontaneously reduced itself. The clinical history suggested that this may have occurred many times before the lesion was found, and it is entirely possible that similar episodes have occurred since her last operation, although subsequent Roentgen examinations have not shown a recurrence of the intussusception.

The cause of the recurrent intussusception was not determined definitely, although the adhesion mentioned above was so situated that it might easily have started the process. The type of gastroenterostomy and size of the stoma seem to be unrelated to the occurrence of intussusception. Re-

verse peritalsis, vomiting or some form of local irritation in the jejunum has been considered as an etiologic factor. Some cases, such as those reported by Gutmann and Jobin,<sup>2</sup> are associated with marginitis, ulcer, or malignancy of the jejunum or of the gastroenterostomy stoma.

The roentgenographic signs of intussusception of the jejunum into the stomach in this patient were: (1) the presence within the lumen of the stomach of a partially movable, filling defect, having parallel curved lines simulating the normal pattern of small intestinal folds; (2) the reëentry of some of the barium which had left the stomach through the pylorus by way of the afferent loop and the stoma; and, (3) delayed gastric emptying. Ledoux et al.<sup>3</sup> have also called attention to a dilatation of the stomach and a displacement of the pylorus to the right.

Sibley<sup>4</sup> reported a case which B. R. Kirklin was able to diagnose and reduce under fluoroscopic manipulation. In our patient, the intussusception had evidently reduced itself following the first gastroscopic examination. In some of these patients, multiple examinations or examination during an attack of vomiting, may be necessary to establish the proper diagnosis.

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# HYDROPS OF GALL-BLADDER IN A FOUR YEAR OLD CHILD

JOSEPH K. NARAT, M.D.

CHICAGO, ILLINOIS

**D**ISEASES of the gall-bladder in children have not been reported frequently and a hydrops in early childhood seems to be a rarity.

J. B., 4 years of age, was admitted to the St. Elizabeth Hospital December 3, 1938. The family and past history were essentially negative. Four days before the boy began complaining of a diffuse abdominal pain returning at intervals of half to one hour. The pains lasted only a few seconds and evidently did not affect the well-being of the child who was active as usual. Appetite and defecation remained normal. On the day of admission the child vomited and began crying out with pain at intervals of ten to fifteen minutes, being playful between the attacks.

The physical examination revealed a well nourished child. The tongue was moist, temperature 99.3, pulse 95 of good quality, respirations 20. All physical findings were negative, except for a slight tenderness over the entire abdomen during but not between the spasmodic attacks. The urine was negative. Hemoglobin was 75 per cent; erythrocytes 4,700,000; leucocytes 11,500, neutrophils 67 per cent, lymphocytes 32 per cent, large mononucleated cells 1 per cent.

The first thought was directed towards an intestinal occlusion by parasites or a foreign body. Although the abdomen was not distended and no repetition of the vomiting occurred, a flat roentgenogram of the abdomen was taken, but furnished no evidence of ileus or a foreign body. Volvulus and intussusception could be excluded in view of the absence of characteristic findings. An infection of the respiratory tract could also be ruled out because there were no subjective or objective chest symptoms and the periodicity of the pains could not be caused by an involvement of the lungs or the pleura. Deep pressure over McBurney's point did not elicit any pain and absence of a localized tenderness or signs of peritoneal irritation eliminated also the diagnosis of Meckel's diverticulitis.

Without a definite diagnosis an expectant treatment consisting of administration of sips of water by mouth and glucose solution by rectum was instituted, but in the course of the next twenty-four hours the condition became aggravated; the temperature remained slightly elevated (99-99.2 degrees) but the pulse rate rose to 130, the child refused drinks and the intensity and frequency of painful attacks greatly increased. A definite tenderness developed in the right upper quadrant of the abdomen and in a lesser degree also in the epigastric region.

Operation was performed under ethylene anesthesia. A right pararectal incision was made with its center at the umbilical line. The appendix was found to be normal and the inspection of other abdominal organs gave negative results with the exception of the gall-bladder which was pear-shaped and very distended, having a diameter of 5 cm. at the fundus—an enormous organ considering the age of the patient. The organ was freely movable and no adhesions or lymphadenopathies could be found. Twenty c.c. of a serous-viscid, nearly colorless fluid was aspirated with a syringe and the cystic and common duct palpated in vain search for a stone. The site of the paracentesis was covered with omentum and the abdomen closed without a drainage. No cholecystostomy was performed because such procedure would offer great difficulties in view of the deep location of the gall-bladder and extreme thinness of the wall and also because it was felt that the condition would subside within a short time. Either a stone in or a cholangitis of the cystic duct must have caused the hydrops. Apparently at the time of the operation the stone was no longer present in the duct and the inflammation of its wall was not intensive as could be judged from the absence of severe reactive signs. Therefore a rapid reestablishment of the patency of the duct could be expected. The postoperative course confirmed the soundness

of this reasoning: the pains did not recur, the child made an uneventful recovery and was discharged from the hospital ten days after the operation. Two weeks later he was in perfect health.

The examination of the aspirated contents of the gall-bladder revealed a serous-mucoid fluid containing few leucocytes and desquamated cells.

#### SUMMARY

A case is reported of an acute hydrops of the gall-bladder in a 4 year old male child. Recovery followed an exploratory laparotomy with aspiration of the contents of the greatly distended gall-bladder. The report seems to be justified in view of the rarity of the condition in early childhood.



MOST surgeons have seen an occasional backache cured by removal of a chronically infected gall bladder.

From—"The Injured Back and Its Treatment" by Ellis (Charles C. Thomas).

# CARCINOMA OF THE AXILLARY TAIL OF THE BREAST

ARTHUR M. DICKINSON, M.D.

Attending Surgeon, Memorial Hospital

ALBANY, NEW YORK

INTEREST in the axillary tail of the human breast was aroused by two cases of carcinoma of this region which came under the author's care. A brief review of the anatomy of the mammary gland and the citation of these two cases are the basis of this paper.

Commonly breast tissue is rather sharply confined to the circumscribed area in the mammary region. The mammary gland itself is usually described as hemispherical in shape with its flat surface resting upon the fascia covering the pectoralis major and its anterior convex surface in relation with the subcutaneous tissues. Mesially, the breast tissue extends as far as the sternum and laterally to the anterior axillary line; it occupies the area between the third and seventh ribs. There are two or more extensions of breast tissue from the main bulk, however. One is directed downward and inward toward the sternum and the other in which we are more interested, extends upward and outward toward the axilla. This extension toward the axilla is sometimes known as the axillary tail. Under some circumstances, this axillary tail may be entirely separate from the bulk of mammary tissue. These extensions of breast tissue are not to be confused with the condition of polymastia, in which there are supernumerary breasts, each with its own nipple, located upon the chest or abdomen; this latter condition is perhaps a manifestation of man's descent from animal.

The axillary tail of the mammary gland extends upward from the main part of the gland, curves about the border of the pectoralis major toward the axillary space, sometimes terminating just below the axilla. It usually is superficially located and not so well concealed by fatty tissue as is the main bulk of gland. It communicates with the

principal mass of breast tissue and drains into the common duct. Rarely this aberrant breast tissue is entirely dissociated from the gland itself and is located beneath the edge of the pectoralis major as a discrete mass.

Obviously the axillary tail of the breast is heir to the same physiologic and pathologic changes as the mammary gland itself. During menstruation it may become enlarged and tender. Likewise, with lactation its cells are stimulated to secretory activity. Its blood supply is less sufficient than that of the breast proper, but the lymphatic channels communicate more directly with the glands of the axilla. In view of the theory that heterotopic tissue is more likely to undergo neoplastic changes than normally placed tissues, one would expect the axillary tail of the breast to show relatively frequent involvement with carcinoma. Such does not appear to be fact, however, if one can judge by the literature and by experience. On the contrary, primary carcinoma of the tail of the breast is quite uncommon.

The symptoms and physical signs of carcinoma of the axillary tail of the breast differ somewhat from those occurring with the usual type of mammary cancer. Discovery of the mass usually takes place at an earlier period on account of the exposed location. This in itself is very helpful in the fight against cancer. The unusual location of the tumor mass may be somewhat confusing when first seen.

It appears to be located too far from the breast itself to be a tumor of breast tissue. The tumor mass is commonly found along the axillary border of the pectoralis major, well up toward the axilla. It may be underneath the edge of the muscle, for the axillary tail occasionally bends underneath the muscle. No connection with the main bulk of breast tissue is evident. In fact, often the



physician does not consider this possibility at all. Just as in breast lesions, pain is uncommon in the earlier stages; tenderness may arise, however, on account of the more exposed location of the tumor. Discharge from the nipple is not to be expected with a tumor located so far from the main ducts. The elevation of the nipple, so frequently seen with primary breast tumors, is uncommon with this lesion because of its relatively distant location. The tumor mass is usually rather hard to the touch; it may be tender. Its mobility will depend upon the duration of the process and the extent of involvement of surrounding tissues. Careful examination of the breast on the affected side is negative as a rule, except possibly for changes of chronic mastitis. Involvement of the neighboring lymphatic glands takes place at an earlier date than with tumors of the breast proper.

Carcinoma of the axillary tail of the breast must be differentiated from tumors arising in the subcutaneous tissue of this region. Benign tumors such as lipoma or fibroma or cysts are very unusual in this location. Ordinarily one has little difficulty in differentiating such tumors from the malignant. Malignant tumors arising from other structures in this area are rare. As lymph glands are seldom found here, tumors of lymphatic origin are uncommon.

In considering treatment of carcinoma of the axillary tail of the breast, one is torn between the conservative and radical viewpoints. Usually local excision of the tumor mass is first done as the essential means of establishing the diagnosis. When the diagnosis is established by frozen sections or later study of the tissues, the problem is to decide if one should proceed with radical amputation of the breast or not. If there does not appear to be evidence of any tumor in the breast, it seems unnecessary to resort to radical measures, providing a wide excision of the primary mass was done. In one of the author's cases, subsequent amputation of the breast was done because of uncertainty of just what was in it. This procedure would seem justified if

the breast does show any suspicious findings. If there is any involvement of the axillary nodes, it would seem safer thoroughly to clear the axilla. The value of radiation therapy requires no discussion; postoperative radiation is the best safeguard against the possibility of recurrence.

#### CASE REPORTS

CASE I. C. L., married female, age 59, was referred to me by her physician in December, 1931 because of a "bunch" in the region of the right breast. She stated that she had noticed the mass about seven weeks before; it was not tender or painful; she did not know if it had increased in size; there had been no discharge. This patient had never lactated. The previous history was negative.

Upon examination a mass 2 by 3 cm. was found in the anterior axillary line, well above the right breast. The mass was hard but freely movable. There was no evidence of involvement of the axillary glands. The right breast appeared negative except for some areas of infiltration such as occur in chronic mastitis.

Several days later, local excision of the tumor mass was done under gas and oxygen anesthesia. At operation the mass was found to be well encapsulated and located under the axillary border of the pectoralis major; it was not particularly adherent and there was no evidence of involvement of the surrounding structures. Microscopic study of the mass showed it to be adenocarcinoma arising in breast tissue. The postoperative course of the patient was not remarkable. In view of the report of malignancy and the question about the right breast, this was amputated three weeks later. Careful study of the removed breast with many sections showed no definite evidence of malignancy; the breast did show changes of chronic mastitis, however. Convalescence from this operation was uneventful. This patient has received no further treatment; recent check-up shows her to be free of any sign of recurrence of the tumor.

CASE II. W. E., a 50 year old spinster was referred June 7, 1932 complaining of a tumor mass of the lower part of the left axilla. The patient stated that about one year previously she had injured this area, but that she had noticed nothing unusual until three months before coming to her physician. At that time a button-like thickening appeared in the skin overlying the axillary fold on the left side.

The swelling had not been red or inflamed; it did not seem to enlarge; there had been no discharge; there never was any pain.

The previous history was essentially negative. Lactation had not occurred; the menopause had been passed two years before and was uneventful.

Examination showed a hard tumor mass, about 2.5 by 2 cm., located in the anterior axillary fold, just below the axilla. The overlying subcutaneous tissue was moderately adherent but the mass was not adherent to the underlying tissues. No glands were found in the axilla. The left breast seemed negative.

A few days later, under anesthesia with gas and oxygen, the tumor mass was widely excised; the breast and axilla were not disturbed. The patient made an uneventful postoperative recovery. Sections from the mass showed a scirrhous carcinoma arising in breast tissue.

Postoperative radiation was suggested but not accepted by the patient. Four months later, there was a questionable mass in the left axilla. In view of this finding, deep therapy was insisted upon and eight treatments were given at weekly intervals with a dosage of 355 R units each time. Under these treatments, the mass in the axilla disappeared.

Recent examination reveals no evidence of recurrence.

#### CONCLUSIONS

1. Carcinoma of the axillary tail of the breast is unusual and offers some difficulty of diagnosis.
2. Wide local excision of the mass, followed by radiation therapy seems sufficient in the absence of evidence of involvement of the breast.



# RUPTURED AORTIC ANEURYSM, SIMULATING RENAL TUMOR\*

SAUL J. PEARLMAN, M.D.

Attending Urologist, Brooklyn Woman's Hospital

NEW YORK CITY

**A**LTHOUGH aneurysm of the abdominal aorta is regarded as comparatively rare, a review of the literature would tend to disprove this impression. Since many cases are not autopsied, and a great proportion of those that are do not find their way into print, it can readily be appreciated that the incidence is far greater than is commonly believed.

McGeachey and Paullin report over 500 cases of ruptured aneurysm in which the diagnosis was made ante-mortem in only nine instances, and they add three correctly diagnosed cases of their own. More discouraging than the failure to recognize the lesion have been the surgical results aimed at its correction.

Perforation of an abdominal aortic aneurysm in a male of 47, simulating a retroperitoneal or renal neoplasm presented an interesting diagnostic problem. Further, our experience with the two common terminal complications, namely, perforation and rupture, prompted this presentation.

## CASE REPORT

A white male, 47 years of age, was admitted to the St. Mary's Hospital, Passaic, New Jersey, on November 5, 1937. He had severe steady pains in the left lumbar region, radiating to the pelvis and accompanied by nausea and vomiting.

Following a high diving stunt twenty-six years before he suffered pain in the left lumbar region which confined him to bed for several days. He felt well after that until five years before admission, when he again experienced an attack of pain in the left side. After a urologic survey in a Brooklyn hospital, he was informed that an enlarged calcified gland pressing on the kidney was responsible for his pain. His last attack immediately prior to admission was so

severe, causing shock and collapse, that immediate hospitalization was advised.

The left eye had been enucleated when the patient was 15 years old, due to an injury sustained when he was 9. Five years before admission he was treated at the Neurological Institute for a paralysis which was attributed to chemical poisoning.

Physical examination on admission revealed a well-nourished, adult male, who was pale, cold and clammy, and apparently recovering from shock. The tongue was dry. A systolic and diastolic murmur was heard at the cardiac apex. The diastolic murmur was transmitted to the axilla, and up into the neck. A diastolic murmur was also heard over the aortic area. The abdomen was tense along the entire left side, and a large tumor mass was palpated in the left lumbar region, this mass being slightly tender, and semi-solid in consistency. The reflexes were present and active.

Shock therapy was instituted. Three days after admission, a urologic consultation and survey was requested by the surgical staff, as a renal neoplasm was suspected. A scout roentgenogram showed a horn-like projection about 1½ by 1 inch calcified, and apparently overlying the second lumbar vertebra, extending out to the lower border of the twelfth rib. Calcification was also noted along the outer margin of the psoas muscle, extending downward in a linear, streaky fashion. While the right psoas border was sharply delineated, the left was completely obliterated, and there was no apparent curvature of the spine. At the time of cystoscopy, ecchymotic areas were plainly visible in the left lumbar region, and over the dorsum penis. The bladder efflux was grossly clear, the mucosa and ureteral orifices were normal in appearance. Indigo-carmin intravenously appeared from the right ureter mouth in eighteen minutes, and from the left in twenty-two minutes, the concentration of dye being stronger on the right. A French No. 6

\* Read before the Section of Genitourinary Surgery, New York Academy of Medicine, February 15, 1939.

shadowgraph catheter passed up the right ureter for a distance of 27 cm., met no obstruction, and there was no retention, the efflux

Wassermann was negative. Three days later, the hemoglobin had fallen to 40 per cent and the red cells to 2,500,000; the white cells were



FIG. 1. Scout roentgenogram showing horn-like calcified process and streak of calcification.



FIG. 2. Bilateral pyelograms showing displacement of kidney and ureter by hematoma, the result of perforation.

on this side being grossly clear. The catheter passed similarly on the left, but aspiration yielded 5 c.c. of retained urine. The roentgenogram with the catheters in situ showed a marked displacement laterally of the left catheter. Bilateral pyelography revealed both pelvises within normal limits, with the left pelvis showing a slight degree of dilatation. The left pelvis was displaced laterally and upward, so that the upper pole of the left kidney almost reached the border of the ninth rib. The lateral deviation of the ureter led us to believe that we were dealing with a retroperitoneal mass, displacing the kidney and the ureter, and causing pressure at the ureteropelvic outlet.

The temperature on admission was subnormal, and reached 100 degrees two days later.

Urinalysis showed acid reaction of the urine and a specific gravity of 1.021; there was a faint trace of albumin and a few hyaline casts. Hemoglobin was 70 per cent; the red count was 3,500,000, the white 15,000, with polys 87 per cent, small lymphocytes 7 per cent, eosinophiles 4 per cent and monocytes 2 per cent. The

17,000 and polys 81 per cent. The low grade temperature and leucocytosis admitted the possibility of an inflammatory lesion, possibly perinephritic. Needle exploration failed to reveal the presence of pus.

The possibilities further considered in the differential diagnosis were: (1) retroperitoneal neoplasm; (2) sarcoma arising from the lumbar vertebra; (3) an old retroperitoneal hematoma, with calcification; (4) a sacculated abdominal aortic aneurysm with perforation. Sarcoma, in view of the long history and general well-being of the patient, was quickly rejected as a possibility. The signs and symptoms pointed to an internal hemorrhage, probably arising in a perforation of an aortic aneurysm, or from a hemorrhagic retroperitoneal neoplasm.

The following day, an extraperitoneal lumbar incision was made under spinal anesthesia. This approach was selected because of the bulging mass in the left flank. A large hematoma, the size of a fetal head at term, was found displacing the kidney upward and laterally, and undermining the musculature of the lateral wall.

After evacuating the hematoma, we encountered a large aneurysm which appeared to be one and one-half times as large as the kidney,

around the aorta and tied just below the renal arteries. The patient died almost immediately afterward. An attempt at transfusion during



FIG. 3. Aneurysmal sac with site of rupture.



FIG. 4. Aneurysmal sac opened exposing large calcific masses.

and which seemed to be bleeding from a perforation on its under and lateral surface. There was no pulsation visible.

The bleeding large aneurysmal sac, the displaced kidney, and the depth of the wound made visualization of the neck of the sac extremely difficult, so that it was decided to apply tamponage to the bleeding point, and approach the problem transperitoneally at a later date.

The patient received an 1100 c.c. direct blood transfusion (two donors) during the operative manipulations, and he was returned to his bed in fairly good condition. He did remarkably well, and six days postoperatively the hemoglobin count rose to 75 per cent, the R.B.C. to 3,800,000 and the W.B.C. to 15,000.

On the ninth postoperative day, the patient suddenly developed signs and symptoms of an unusually severe internal hemorrhage, which was ascribed to rupture of the sac. The long duration of the aneurysm led us to feel reasonably certain that collateral circulation was established, and that ligation of the aorta might be attempted. He was, accordingly, taken to the operating room, and explored transperitoneally. The sheath of the aorta was incised, a heavy No. 6 braided silk ligature passed

this procedure was unsuccessful, because of the collapsed condition of the veins.

The pertinent findings at autopsy (Dr. Kastler) were:

The pleural cavities contained no free fluid. The lungs were very pale, with small atelectatic areas present in the lower lobe. There was no evidence of infarction or pneumonic infiltration.

The pericardial sac contained the usual amount of clear, straw-colored fluid. The visceral and parietal pericardium were smooth and shiny. The visceral pericardium showed some fibrous thickening. The heart was very much enlarged, and showed all signs of a symmetrical hypertrophy. The heart muscle was very pale, and the valves were thickened. The aorta and coronary vessels showed an arteriosclerotic process.

The most striking finding on opening the peritoneal cavity was a large, extraperitoneal mass that filled practically the entire left side of the abdomen, pushing the spleen and kidney upward and displacing the small intestine to the right. On close inspection, the mass was found to be a large hematoma originating from a huge aneurysm of the descending aorta that had ruptured toward the left. The aneurysm was found to be about the size of a child's head

and had developed at the region of the celiac axis. The descending aorta and sac of the aneurysm showed arteriosclerosis and calcification to a pronounced degree, and the formation of large atheromatous plaques. The aneurysmal sac was devoid of intima and was lined with laminated thrombi. On the left side of the aneurysm a recent rupture about 2 inches long was found. Microscopic examination of the aorta showed diffuse arteriosclerosis. The cause of death: ruptured aneurysm of the descending aorta.

#### COMMENT

This case emphasizes the fact that aneurysms of the abdominal aorta may exist for lengthy periods and remain relatively asymptomatic, until terminal complications occur. The clinical manifestations, when present, are due for the most part to pressure on neighboring organs. Ureteral obstructions with hydronephrosis, vertebral erosions with root pains or paraplegia, intestinal or gastric obstruction, and portal, splenic or mesenteric vein thrombosis are some of the conditions which may indicate the existence of this lesion.

Syphilis, the cause of most aneurysms, was in this case excluded by the history, and the clinical and serologic findings. The extreme degree of calcification and the sclerotic changes in the aorta and coronary vessels suggested arteriosclerosis as a possible underlying cause. The history of trauma sustained twenty-six years previously appeared highly significant. Injury to the aorta with resulting intramural hemorrhage and fibrosis could result in a site of lowered resistance in the wall of the aorta. The latter, yielding to the high intra-aortic pressure, could very well have resulted in the aneurysm.

Perforation with gradual bleeding into the retroperitoneal tissues, or sudden explosive rupture with extensive hemorrhage resulting in sudden death, are the two terminal complications, both of which occurred in our case.

The long duration of the lesion and the thought that collateral circulation had possibly been established, plus the fact that

the patient was certain to bleed to death in a few minutes, were the factors that influenced us in attempting ligation. Ligation of the abdominal aorta carries with it a very high mortality, and although Matas, in his exhaustive chapter on aneurysms in Keen's *Surgery*, offers the hopeful suggestion that gradual occlusion may solve the problem, this view is not shared by research workers in the field of aneurysmal surgery. It is their opinion, that ligation of the abdominal aorta below the inferior mesenteric artery taxes the heart with so enormous an amount of work that only an absolutely and functionally capable organ outlives the strain and death ultimately ensues from cardiac failure.

According to Matas, the abdominal aorta has been ligated fifteen times since Sir Astley Cooper performed the first operation in 1817. Death followed in each case, though the end was delayed to the forty-eighth day in W. W. Keen's case, and to the thirty-fourth day in Tillaux'. If the patient survives the cardiac strain, which is extremely rare, he still has to face the prospect of sudden death as a result of rupture or ulceration of the aorta at the site of the ligation.

Recent reports in the literature would seem to indicate that this problem, which has baffled the surgical world, is being overcome. I refer particularly to the work of Blakemore and King, who have evolved a method of wiring aneurysms. With this method they are able to determine: (1) the variety of aneurysms; (2) approximately the amount of wire that will be necessary to impede the blood flow; (3) the occurrence of mass clotting of aneurysms if a final segment of wire requires only from 3 to 4 amperes for heating to 80°C. The average amount of wire used in the eleven cases reported was 118 feet. Of these eleven cases, there were four deaths and seven survivals. Two were abdominal aortic aneurysms. Both were wired and heated to 80°C. One patient has been symptom-free for two years, while the other was alive and well eight months postoperatively. They

conclude that a thoroughly clotted aneurysm may be inactivated indefinitely, that their method and technique is safe and efficient that heating wire to 80°C. causes a heat inflammation which promotes adherence and organization of the clot deposited, and that the absence of signs and symptoms of growth and relief of pain in seven living patients operated upon by their method justifies the recommendation of this procedure.

#### SUMMARY AND CONCLUSIONS

1. This case is reported because of the unusually long duration of an abdominal aortic aneurysm, traumatic in origin.

2. The diagnosis was suspected preoperatively from the clinical history, the urographic and roentgenologic findings, and the presence of a tremendous hematoma occupying the entire retroperitoneal space. The diagnosis was further strengthened by the fact that there was no evidence of lues.

3. Ligation of the abdominal aorta was attempted.

4. The electrothermic coagulation method of treating aneurysms offers greater promise of relief and cure than any of the measures employed heretofore.

5. Earlier diagnosis will afford opportunity for therapy before terminal complications occur.

The writer wishes to express his deep appreciation to Dr. B. Willis, Attending Surgeon, St. Mary's Hospital, Passaic, for permission to report this case, and for his helpful suggestions in the operative and postoperative management.

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# NEW INSTRUMENTS

## A NEW APPARATUS FOR WELL LEG TRACTION

MACLYN BAKER, M.D., F.A.C.S. AND STUART ZEH HAWKES, M.D., M.SC.D., F.A.C.S.

IRVINGTON, NEW JERSEY

NEWARK, NEW JERSEY

THIS apparatus is similar in principle to other types of traction appliances in which the well leg is used to fix and reduce the injured leg, using the pelvis as a fulcrum. It is easy to apply and simple to construct. The cost of assembly is small. It can be built by any carpenter, or even a physician who can use tools fairly well.

*Description.* The apparatus was first built by one of the authors (M. B.), following a suggestion of Dr. N. A. Carey of Oakland, California. It resembles a trapezium with parallel sides of unequal length, the shorter side at the top. The non-parallel sides are equal in length and converge towards each other from below upward. The corners are hinged. A screw turnbuckle joins opposite corners of the parallel sides. The construction is of wood. (Fig. 1.) At first it was incorporated in the outer layer of padded plaster casts applied to both legs. By the action of the turnbuckle the well leg was pushed upward and the injured leg drawn downward. Later the wooden sides which formerly were incorporated in the casts were made wider and were hollowed out so as to fit the outside of the casts. Four metal posts, two on each side, were added, having a knob at one end and a slot at the other. The ends of the posts were turned back to keep the attached bands from slipping. These metal bands had a number of eye-holes at one end and a wing nut at the other. The length was adjusted by choosing the correct eye-hole passing the band around the cast and tightening the wing nut to the other end of the post. This modification was made to provide greater flexibility by allowing

reapplication or additional adjusting without removing the casts. Experience proved that at times readjustment became necessary to obtain satisfactory reduction of the fracture. This was impossible without removing the outer layers of the casts. An added consideration was that the casts became less heavy and cumbersome. The end between the knees later was made adjustable to allow for longer and shorter legs. It was realized that the distance between the knees varied with the length of the legs.

*Method of Application.* Padded casts are applied to both legs, from the base of the toes to the knees. Starting with stockinet followed by several layers of glazed cotton, the points of greatest pressure are next protected by covering them with  $\frac{1}{4}$  inch felt. These danger points are: on the well leg the heel, the bottom of the foot, and the medial side of the leg and knee; on the injured leg the medial side of the knee and leg, the heel, and the dorsum of the foot. Gauze bandages are wound tightly around the padding to reduce the bulkiness. After placing a moulded plaster splint on the inside of the leg and the bottom of the feet plaster bandages are applied. About six 4-inch plaster bandages are used for each cast. The plaster is allowed to harden for several hours to avoid denting, which might occur if the apparatus were applied immediately before the plaster had set. The distance between the patient's knees is gauged with the apparatus in place and the upper bar is adjusted to meet the distance correctly. The bands are passed around the casts. The closest eye-



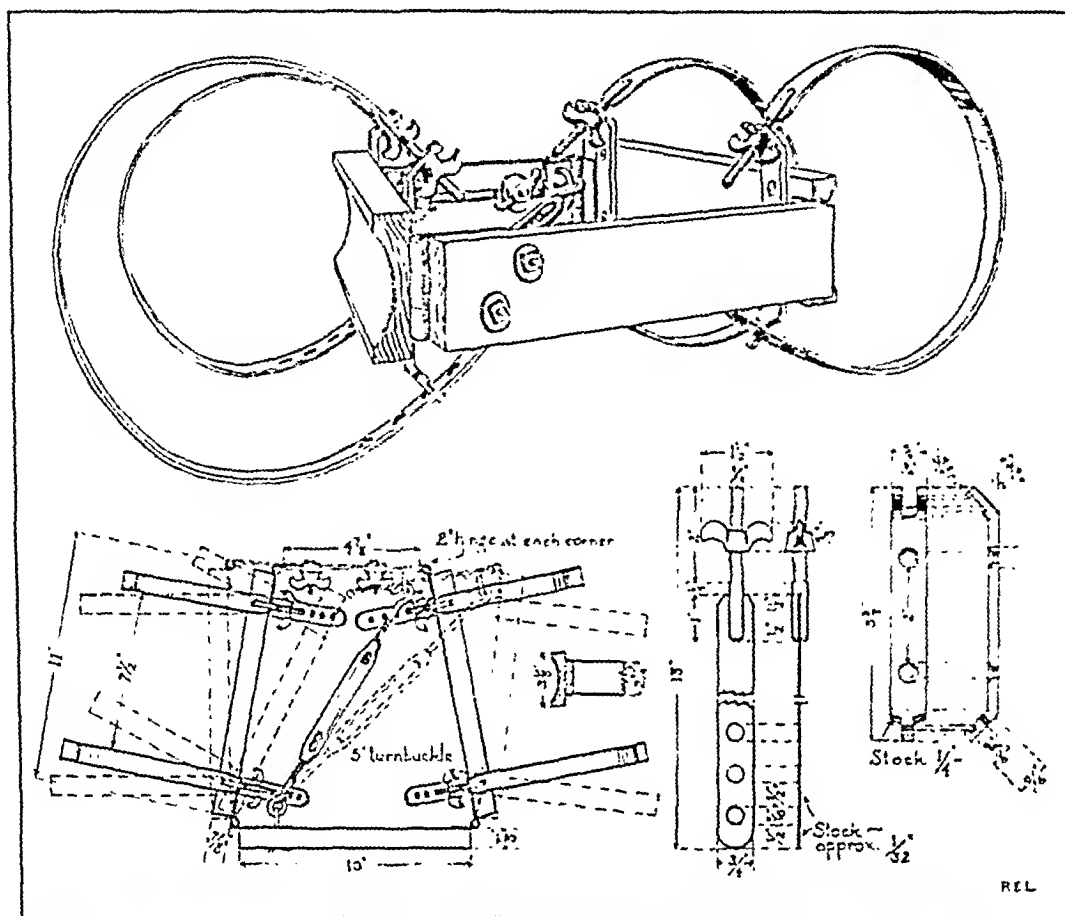


FIG. 1. Apparatus shown above; construction plans and measurements below.



FIG. 2. Showing apparatus in position. Patient in wheelchair.

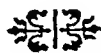
hole to size is chosen, and the screw nuts tightened to the metal posts. The turn-buckle is now tightened slowly, giving several turns two or three hours apart. Reduction is thus accomplished slowly over a period of ten to twelve hours to avoid producing unnecessary muscle spasm or displacement of the bone fragments. If the patient's condition permits, reduction may also be effected immediately by the Lead-better maneuver carried out under local anesthesia. In the latter instance the turn-buckle is immediately tightened sufficiently to maintain the reduction. As soon as the fracture is considered satisfactorily reduced, one turn of 2-inch plaster is placed over the bands to keep them from sliding on the cast. This is done because the patients are turned frequently and are also moving about in wheel chairs. The screw bolts also sometimes loosen and allow the bands to slip in spite of careful supervision.

*Type of Fracture.* The apparatus is used in fractures of the upper end of the femur, both extracapsular and intracapsular. Intertrochanteric fractures unite readily if well reduced. This method is ideal for them.

Fractures of the neck of the femur have advocates for operative and nonoperative treatment. If insertion of a pin or nail is not proposed, the results will be as good with this method as with other nonoperative procedures. Over 100 cases have been treated. The treatment differs very little from the general principles of fracture care, so that a detailed discussion is unnecessary. Immobilization is maintained the necessary length of time, depending on the site of the fracture, the age, the general condition of the patient, and the findings in subsequent x-rays.

#### SUMMARY

1. A new apparatus for well leg traction is herewith presented.
2. In over 100 cases the results have been found as satisfactory as with other nonoperative methods.
3. The construction is simple and economical, adapting it to wide usage.
4. Its mode of construction, method of application, and type of case for which suitable, are described.



# NEW APPARATUS FOR STORING, FILTERING AND ADMINISTERING BLOOD

WARREN B. COOKSEY, M.D., F.A.C.P.

DETROIT, MICHIGAN

FOR the past year this apparatus has proved extremely satisfactory in the administration of over 4,000 transfusions from the blood banks of Harper Hospital, Grace Hospital and Receiving Hospital, Detroit, Michigan. It permits of a completely airtight system for taking and storing blood that is simple, inexpensive and practically foolproof. After substituting the internal filter cork when ready to administer, the operator can give blood with the same ease as that of glucose infusion. By this airtight method transfusion reactions have become a rare occurrence.

In the diagram, "C" represents the suction apparatus in place ready to draw blood. The 600 cc. bottles are autoclaved containing 70 cc. of 2.5 per cent sodium citrate ready for use. To draw blood, the double needle, "D," of the suction apparatus is pushed through the hole in the metal disc, and on through the small rubber plug, "b," just as one penetrates a rubber-stoppered vial. When the donor needle is in the vein, occasional compression of the rubber bulb provides ample, but never an excessive, amount of vacuum. Occasional twirling of the flask properly mixes the citrate and blood. When sufficient blood has been obtained, the suction apparatus is withdrawn, thus automatically sealing the flask so that at no time is room air able to enter the flask of blood. In the preparation of

plasma reserves, this same apparatus is used to withdraw the supernatant plasma from all stored blood reaching seven days old.

"D" illustrates the simple structure of the suction apparatus. A continuous fifteen-gauge needle conveys the blood into the bottle; while an eighteen-gauge needle, which is fused to it, withdraws air from the bottle when the rubber bulb is compressed. Especially constructed ball bearing valves prevent air from entering the bottle.

"E" shows the assembly of the donor bottle closure, "a" being the solid rubber closure cork, while "b" is a soft rubber plug ( $\frac{1}{4}$  by  $\frac{1}{2}$  inch) which fits snugly into the depression of "a." The metal disc, "c," perforated in the center, holds the plug, "b," firmly in place, while the screw top, "d," fixes the entire closure, ready for use. The plug, "b," is a special vial-type rubber and may be used a number of times before replacing.

"B" represents the internal filter cork, which is put in place just before giving the blood. The filter is reinforced 100 mesh stainless steel, which is easily removed for cleaning, is practically indestructible and never becomes clogged. A glass breather tube permits administration by gravity by a simple intravenous tubing set as shown in "A."

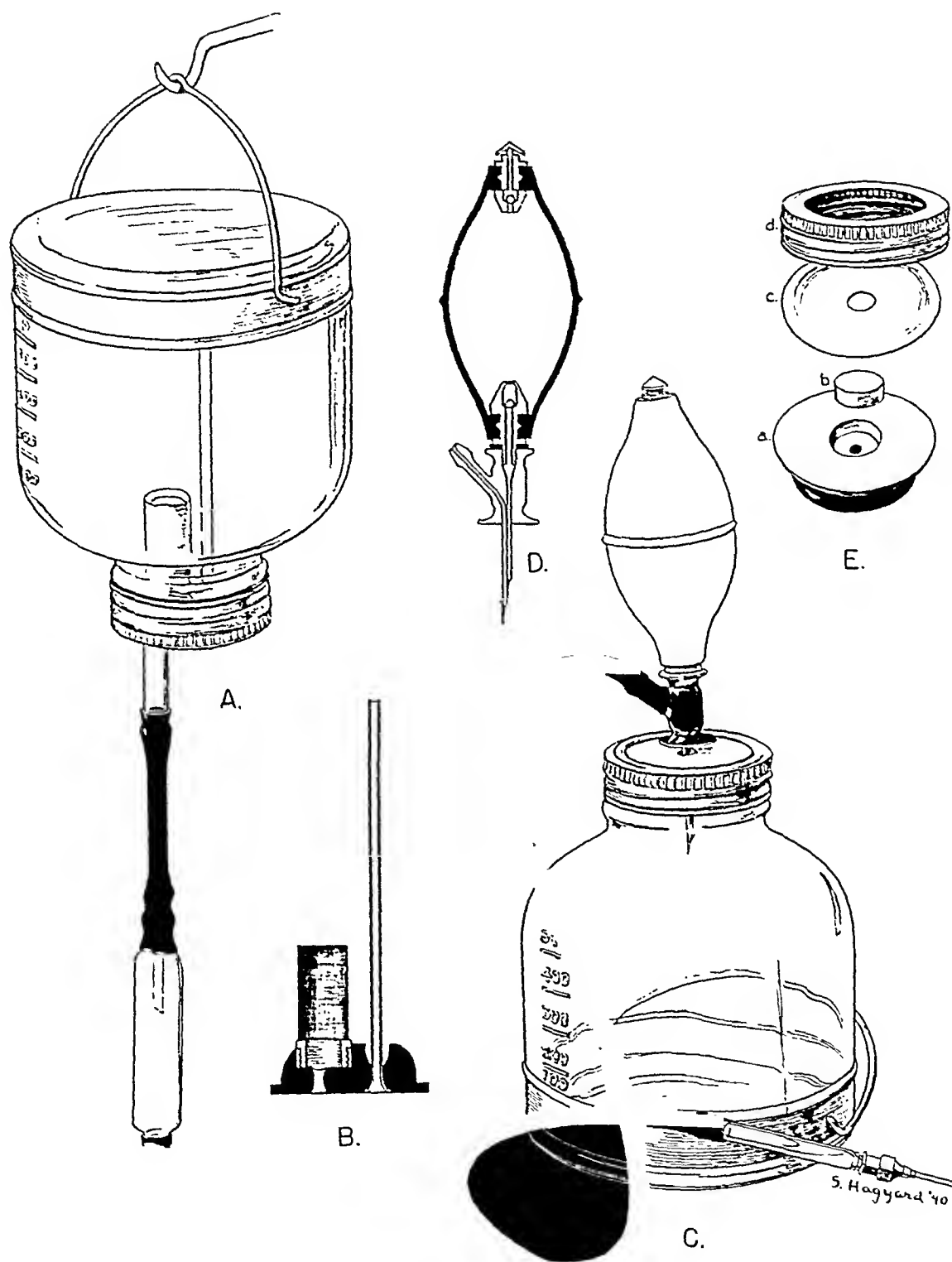


FIG. 1. A, method of administering the blood by gravity; B, internal filter cork assembly; C, suction apparatus in place ready to draw blood from donor or supernatant plasma from stored blood; D, structure of suction apparatus; E, assembly of cork used in taking and storing blood.

# A MAGNIFIED OPERATIVE FIELD

DONALD W. MACCOLLUM, M.D., F.A.C.S.

Associate in Surgery, Harvard University Medical School; Associate Visiting Surgeon, Children's Hospital; and Junior Associate in Surgery, Peter Bent Brigham Hospital, Boston

BOSTON, MASSACHUSETTS

THE use of the binocular loupe for magnification of small objects has been of great advantage to workers in many branches of science. In recent years, a standard model loupe with open sides has been manufactured by various optical firms and has been accepted by those surgeons who at times require magnification of certain structures in their operative fields. This standard loupe projects approximately 4 inches ahead of the face and consists of two small prisms supported on two converging stalks that attach solidly to the bridge of the wearer's regular glasses.

Although this loupe serves to magnify a portion of the operative field, it has several disadvantages: (1) The area enlarged is often too small to be useful in a great many types of work. (2) The lenses are small, so that they occupy only the center of the normal visual field. The constant change in focus from the peripheral to the central field is likely to be disturbing to the wearer if it is necessary to work with these glasses for a long period of time. (3) The supporting structure for the lenses is heavy and, being attached to the bridge, falls in the field of vision. (4) The glasses are not sterile and are likely to be touched by the operator or his assistant. (5) For the stages in the work in which the wearer does not need any magnification it is impossible to get rid of the magnified portion without removing or changing entirely the pair of glasses.

In order to eliminate some of these difficulties, a new type of binocular loupe was designed by the author and built by A. E. Covelle of Boston. A heavy steel frame was fit with the author's corrected lenses. Across the top of this frame a hollow brass rod was soldered with a small platform on

each end. Reinforcing side struts were carried down to each ear piece. A tape was attached from the center of this cross-bar to pin to the operator's cap, thereby balancing the weight of the loupe and taking the pressure off the bridge of the nose. This part of the apparatus is unsterile and is put on before the surgeon starts to scrub. (Fig. 1.)

When the stage of operation requiring enlargement is reached, the nurse lifts the second portion of the loupe from a sterilizing solution, dries and attaches it. (Fig. 2.) This second sterile unit is made up of two large magnifying glasses cemented into a solid frame. At one end of this frame are two clips that fit and clamp down tightly into the two end platforms of the first piece. The nurse is able to attach this sterile part to the foundation glasses without contamination of either herself or the enlarging apparatus. The magnifying lenses are on a swivelled bar held in place by side springs so that the operator may turn them up out of the field or down without danger of contamination. (Fig. 3.) Because the lenses are much larger than those in the standard loupe and are butted together in a line corresponding to the exact center of the operator's face, the entire central visual field is magnified. The change from the magnified field to the normal field is then easily made by turning the lenses up out of the line of vision. (Fig. 4.) The supporting structure for this whole apparatus is out of the normal visual field, therefore, does not disturb the wearer. Because the projecting portion is sterile, contamination from touching the loupe is eliminated. When the operator reaches the stage when magnification is no longer needed, he may continue to wear the loupe turned up out of the way,



FIG. 1. The basic unsterile unit in place. Note cross-bar with end plates where the junction is made with the sterile second unit.



FIG. 2. Nurse applying sterile magnifying apparatus. With care this is done without contamination and does not appear as perilous as in this photograph.



FIG. 3. Entire unit in place for working in a magnified field. Operator, upon raising his eyes, sees directly in front of him through a normal field.

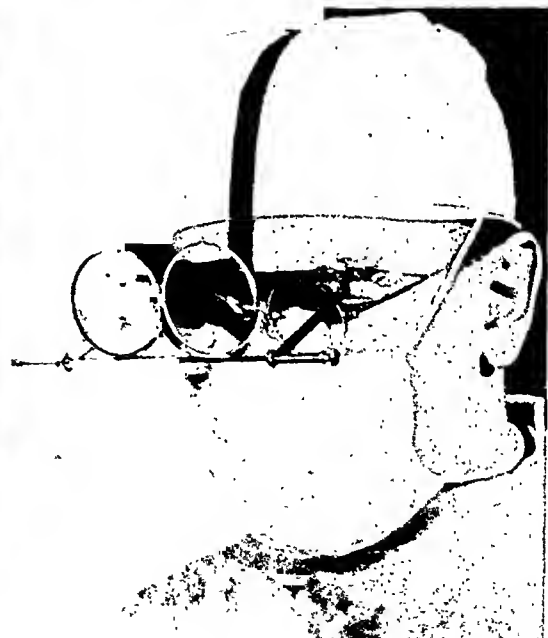


FIG. 4. Magnifying loupe has been turned up by the operator so that the central visual field is now normal. He may turn this down again at will without contamination.

or it may be unclipped by the circulating nurse, leaving the first portion with his normal corrected lenses in place.

In the author's loupe the glasses of the projecting portion consist of two plus four biconcave lenses set forward 2.75 inches from the basic unit. This arrangement produces a depth of reasonably sharp focus, approximately 1 foot. It is, therefore, not necessary for the operator to remain in a fixed position since movement of the head within this 1-foot range does not tend to

throw the structures in the operative field out of focus.

As far as can be determined all the disadvantages of the standard loupe have been eliminated with this type of glasses. It was designed principally for use in plastic surgery in which it is frequently necessary to change from the normal to the magnified field for fine, minute work. It has proved so advantageous to the author that it was thought it might be useful to workers in plastic, and other fields of surgery.



THE potentiometer indicator is an instrument which was devised to make direct readings of the skin temperature. It is similar to the dermatherm and consists of a galvanometer and thermocouple arrangement. From—"Peripheral Vascular Diseases" by Kramer (Blakiston).

S P E C I A L M O N O G R A P H

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The  
Diagnosis and Treatment  
of Hyperthyroidism and  
Associated Conditions

BY

ARTHUR GOETSCH, S.B., M.D.



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# THE DIAGNOSIS AND TREATMENT OF HYPERTHYROIDISM AND ASSOCIATED CONDITIONS\*

ARTHUR GOETSCH, S.B., M.D

BROOKLYN, NEW YORK

**G**OITER unqualified, is an enlargement of the thyroid gland. Hyperthyroidism or thyrotoxicosis denotes a toxic state due to an excessive amount of thyroid hormone in the circulation. It results from overactivity of the thyroid gland regardless of the fundamental pathology. The specific thyroid hormone, thyroxin, is an immensely potent drug and an exceedingly small fraction of a grain is capable of producing nervous symptoms even in a normal person. When thyroxin accumulates in the circulation in excessive amounts, a high degree of hyperthyroidism is produced; and when diminished amounts are present, varying degrees of underfunctioning or hypothyroidism result. It is likely that the various types of toxic goiter secrete bodies similar to thyroxin since the symptoms produced, while not wholly identical, are similar to those which can be caused experimentally by overdoses of thyroid extract and thyroxin. In dealing with goiter and hyperthyroidism, therefore, we need not discuss the matter of a so-called "dysthyroidism," due to an altered secretion, but keep in mind the probability of toxic bodies analogous chemically and pharmacologically to the pure crystalline thyroxin first isolated by Kendall. It follows obviously that treatment is designed to abolish the excessive secretion.

In considering the pathological anatomy, the physician must think in terms of both gross and microscopic changes in the gland for the two are interrelated. Furthermore, to obtain a proper understanding and evaluation of the various types of goiter one must constantly keep in mind the fundamental pathology, since a classification based on other than basic structural factors can be only confusing and misleading. Reference to the embryological development of the thyroid and a consideration of the evolution of the various types of goiter in the normal thyroid is not only

\* From the Surgical Departments of the Long Island College Hospital and the Long Island College of Medicine, Brooklyn, New York.

helpful but essential to a clear understanding of the problem of hyperthyroidism.

The original thyroid anlage is composed of an undifferentiated, structureless mass of cells which (1) develop into small acini surrounded by a single layer of epithelial cells containing a characteristic colloid, and according to some authors (2) form nests of fetal epithelial cells—the interstitial cells of Woelfler or embryonal rests of Cohnheim—which remain scattered throughout the gland between the normal acini. The rests of Cohnheim do not take part in the formation of the normal thyroid acini or in the production of colloid but lie latent in most persons throughout life. Keeping in mind the two types of cells just mentioned, namely, (1) the acinar or parenchymal thyroid cell and (2) the interstitial or fetal cell, we may now consider the origin of the different kinds of goiter from these two types of epithelial cell.

#### TYPES OF HYPERPLASIA

*Mild Hyperplasia of the Puberty Type* is sometimes called the goiter of adolescence, or erroneously “physiological overactivity.” It represents the first stage in the proliferation and hyperplasia of the normal acinar cell. The condition occurs usually in young girls at puberty or soon after. There is usually a mild hyperplasia and hypertrophy of the thyroid, with possibly a slight increase in the blood supply without, however, frank thrills and bruits. Microscopically, there is an increase in the size of the cells of the acini with a moderately increased alveolar infolding and occasionally an increase in the colloid content. The thyroid is fairly firm and elastic. Such a gland produces a mild hyperthyroidism which expresses itself in increased nervousness and irritability, a high-strung temperament, a mild emotionalism, a mild tachycardia, occasional palpitation, slight dyspnea, fatigability, vasomotor instability and a mild tremor. While the eyes may show increased brightness, there is usually absence of frank exophthalmos. The symptomatology tends to great variability and its relative mildness should be emphasized. In some cases it is almost entirely subjective and can be elicited only by painstaking and patient questioning. It is questionable whether one should regard the milder forms as due to true pathological changes or simply as expressions of transient, heightened, physiological activity. Many cases of this kind undergo spontaneous cure. However, it is by no means wise to assume that because of the comparatively mild

symptomatology and the slight enlargement of the thyroid that the patient will necessarily outgrow the condition.

*Exophthalmic Goiter.* (Synonyms: Von Basedow's disease, Graves' disease, diffuse hyperplasia, vascular goiter, etc.) This group represents the most complete expression of the advanced stages of hyperplasia and hyperthyroidism. The thyroid gland is symmetrically enlarged and presents a marked increase in its circulation as evidenced by the presence of thrills and bruits over the superior poles and often over the gland itself. The increased vascularity may even extend to the surrounding tissues. In the beginning, the gland is usually soft and elastic. Later it becomes firm and granular. The parenchymal or acinar cells enlarge, multiply and become tall and columnar. The acini lose their characteristic normal spherical configurations and assume various shapes with marked distortion and infolding of the alveolar walls. Furthermore, the colloid content of the acini is diminished. Groups of lymphocytes are occasionally present but are hardly characteristic.

*Predisposing Causes.* Sexual cycles—puberty and the menopause—undoubtedly play a part in some cases. In 1928, Warthin<sup>1</sup> described a type of person that by nature is predisposed to hyperthyroidism.

The present day conception of Graves' disease is that of an extremely variable and broad syndrome. If we consider this clinical syndrome analytically we see that there is presented the clinical picture of a well-defined type of human individual—a distinct pathological constitution. This fact has not hitherto been recognized by American writers on goiter, but in Europe, both in Germany and in Italy, various writers are beginning to speak of the hyperthyroid constitution, (or Graves' constitution, as I have preferred to call it) in the absence of any positive proof that thyroid hypersecretion is its underlying etiological factor.

The Graves' constitution individual presents a youthful build with a slender, delicate and soft skeleton, slender waist, . . . long slender fingers and toes with pointed terminal phalanges, abundant hair, and well-developed teeth and nails. The muscles are long and thin; there is underweight rather than overweight. . . . The facies is that of a bright-eyed, snappy, vivacious, quick-reactioned, ingenuous, often very attractive, youthful or childish appearance; . . . Muscle weakness is a common symptom. The skin is usually warm and moist, fine, delicate and translucent; . . . Hyperidrosis is common, and also dermatographism. . . . There is a marked instability of the central nervous system, in the form of increased sensibilities and emotional response, quickness of perception and reaction.

. . . In the majority of cases the marked irritability of the sympathetic system is a predominant characteristic. . . . Summing up the most striking and characteristic features of this constitution, we find them expressed in juvenile morphology and rapid functional reaction.

Racial factors, "autonomic imbalance," the hyperthyroid temperament and the so-called Graves' constitution as noted are important. Focal infection is sometimes mentioned as a cause though without compelling evidence. In the course of treatment, many patients have had various foci of infection removed: teeth have been needlessly sacrificed, sinuses drained, tonsils and adenoids and even gall-bladders have been removed. In our opinion there is no evidence that focal sepsis predisposes to goiter. However, the role of sepsis and infection in exacerbating an existing hyperthyroidism is frequently borne out particularly during epidemics of influenza. The disease may affect several members of the same family. We have seen it in grandmother, mother and child. The sex element is attested by the great predominance of women over men.

*Signs and Symptoms.* Graves in his original description of exophthalmic goiter recognized a classical triad of cardinal symptoms—tachycardia, exophthalmos and goiter. Charcot added a fourth symptom—tremor.

*Onset.* The onset may be acute but more often it is insidious. When symptoms develop abruptly, they usually follow severe emotional strain such as fright, anger and profound grief particularly in persons conditioned and predisposed by "Graves' constitution." However, it is generally possible to uncover a latent period of mild hyperthyroidism antedating the sudden exacerbation. Remissions followed by recrudescences are common. Once the condition is frankly expressed, spontaneous and medical cures are rare and unless surgical relief is obtained, chronic invalidism with eventual physical dissolution or severe and even fatal crises may result. A classical, fully developed case presents little or no difficulty in diagnosis. However, in its incipiency, the condition is frequently overlooked. Hence one should watch for early signs and symptoms. It has been said that in its early stages, exophthalmic goiter is more a disease of the patient than of her organs. A patient's attitude, her approach to the physician, the dilated pupils, the restlessness, the purposeless rapid movements, the euphoria, the warm, moist, hands, the flushed face and the patient's haste may all be significant long before goiter can be detected. When to these suggestive signs are added unexplained loss of

weight, dispositional and temperamental change, emotional instability and uncontrolled energy, exophthalmic goiter may be lurking and should be suspected.

*Early Vascular Signs and Symptoms.* Increased pulse rate is frequently one of the earliest signs and may lead to "heart consciousness." (The average person at rest is of course ordinarily not conscious of his heart action.) In the beginning, the rate is regular and may rise from 80 to 90 and gradually increase to 120 or more. The heart may show little except an accelerated action. One should be careful in the evaluation of apparent murmurs since functional murmurs are fairly common. When true murmurs are present, they are due to other causes such as rheumatism and previous systemic infections. When the disease is fully expressed, visible cardiac pulsations over the precordium are greatly increased and the heart action is heaving and forceful. Likewise, the neck vessels throb forcibly. Thrills and bruits are commonly present over the thyroid particularly over the upper poles. They result from increased functional activity of the gland which, because of the hyperplasia, demands an increased blood supply.

*Exophthalmos and Other Ocular Signs.* The characteristic staring expression results from the protrusion of the eyeballs and the resultant exposure of the sclerae above and below the corneae (exophthalmos). In rare cases, severe conjunctivitis, corneal ulceration and panophthalmitis may develop. The principal characteristic eye signs in addition to the exophthalmos are von Graefe's sign, or the incoördination of the eyeball and eyelid when the patient glances downward; Stellwag's sign, or the widening of the palpebral fissure with infrequent winking; Moebius' sign, or the lack of power of convergence on near objects. The ocular signs result from weakness and incoördination of the extrinsic muscles of the eyes. The occurrence and unilateral exophthalmos while relatively uncommon is by no means rare. No satisfactory explanation exists for this peculiar phenomenon. (Fig. 1A and B.)

*Goiter.* The earliest cardiac and nervous symptoms usually antedate the appearance of goiter. In many cases thyroid enlargement may be mild or absent and varies widely in the same individual over a period of time. In the majority of cases, however, an enlarged gland can be demonstrated without difficulty and enlargements three or four times normal are not infrequent. It should be stressed that there is no quantitative relationship between the extent of thyroid

enlargement and the degree or duration of the symptomatology. Indeed palpable thyroid enlargement is not necessary to make a diagnosis.



FIG. 1. S. H. A, age 28. Exophthalmic goiter with unilateral exophthalmos.  
B, age 29. Photo taken six months following bilateral resection. The right eye is still slightly prominent.

*Tremor.* The characteristic fine (though at times coarse) vertical tremor of the extended fingers is almost invariably present. It is involuntary, though accentuated by voluntary effort and averages seven to nine or more oscillations per second. Tremor may extend to the forearms, legs and in fact to practically all of the body musculature. A peculiar quivering of the lips when the patient speaks is frequently noticed in the unusually active case.

*Other Signs and Symptoms.* One of the earliest symptoms commonly encountered is weakness or asthenia. In fact it may take precedence over the customary nervousness. The patient complains of being tired most of the time and may not be refreshed by a night's rest. In severe cases, the muscular weakness is so disabling that the patient may feel as though her legs were unable to support her. Loss of weight is common especially when there is greatly increased metabolism. One should be doubly suspicious when the loss of weight occurs in the presence of a voracious appetite and good digestion. Flushing and sweating are common and pruritus is occasionally encountered. Acne, comedones and erythematous lesions of the skin are fairly common. Irritability of temper, dispositional change, depressions and moods are frequently present long before other more definite symptoms occur. Thus for example, a housewife without



apparent cause may become cross with her family or impatient with her children. Memory change is fairly common. The patient may forget her appointments and misplace ordinary objects of daily use.



FIG. 2. J. P. A, age 44. Preoperative photo. Typical Graves' disease with classical symptoms. Basal metabolic rate +101 per cent. B, same patient, age 47. Photo taken three years following bilateral resection. Patient's health entirely restored.

Marked restlessness, disturbing dreams and great apprehension are other symptoms. The patient may dread the ordinary routine of life such as telephoning to and meeting her friends. She is very apt to look upon the serious side of life. Phobias are common such as the fear of going insane. Nausea, vomiting and severe diarrhea with great emaciation may occur in the highly toxic cases. These manifestations are to be regarded as ominous.

*Course.* The course varies. The onset is usually insidious. Remissions are fairly common but it is rare to have all of the symptoms disappear. The cases beginning in early adult life seem to progress less favorably than those developing in the later decades. If allowed to run its course, the disease is usually fatal. Death results from myocardial degeneration and cardiorespiratory failure. A number may end in "burnt-out" thyroids, indicating that the hyperthyroidism has spent itself. The patient, however, remains a permanent cardiovascular invalid. An occasional case may end in myxedema. (Fig. 2A and B.)

## OTHER TYPES OF HYPERPLASIA

The task of detailing the signs and symptoms would be simple indeed if every case or even most of the cases that are seen in practice conformed to Graves' original description. We have described the milder forms of hyperplastic enlargement commonly referred to as puberty hyperplasia and the typical, full-blown hyperplasia known as Graves' disease (Basedow's disease or exophthalmic goiter). It naturally follows that there are certain intervening stages of differing severity in which the thyroid shows varying degrees of hyperplasia between the very mild and the extremely active and fulminating types of exophthalmic goiter. The clinical activity in these moderate hyperplasias varies within wide limits but in general it is proportional to the degree of the hyperplasia. Many of the symptoms of Graves' disease are present. However, they are present in less active and impressive form. Thus the pulse rate, loss of weight, tremor and general nervousness are not as severe. It is mainly by the diminished severity of the symptoms and the absence of the characteristic ocular signs that the moderate hyperplasias are differentiated from Graves' disease. Thrills and bruits, though they may be present, are likewise less marked than in Graves' disease.

## ADENOMA OF THE THYROID (SYNONYM: NODULAR GOITER)

Thus far we have spoken only of the types of hyperthyroidism that result from hyperplasia of the alveolar cells and we recognized (1) the mild first stage or puberty hyperplasia, (2) the extreme hyperplasia of Graves' disease, and (3) the intervening types of moderate hyperplasia of varying degrees of clinical activity. Next we should consider a very different type of pathology, namely, the benign, new growths or adenomas which originate according to some authors not from the acinar cells but from the interacinar interstitial epithelial cell rests of Woelfler. These cells are present in all normal glands and because of their loose structure and the fact that they do not take part in the formation of normal thyroid acini, are regarded as lying dormant and inactive. They resemble embryonic thyroid cells and are, therefore, referred to as fetal cells. When one or more of these interstitial cell groups begin to grow, a mass of cells is developed. The mass which at first is microscopic in size, grows until it develops macroscopic proportions. Nodules may occur as single or multiple adenomas. As they increase in size, the

contiguous thyroid parenchymatous tissue is compressed and may undergo pressure atrophy. Gradually, through a deposit of connective tissue, a capsule forms about the newly developed tumor. Early encapsulation is characteristic of adenoma. In the beginning the adenoma is firm and smooth. However, since we are dealing with neoplasia, we may in time expect the usual sequences of neoplastic disease. First, fatty degeneration with central autolysis and fluid accumulation takes place (cyst-adenoma). This may in time be followed by hemorrhage into the interior (hemorrhagic cyst-adenoma), or the lesion may undergo fibrosis and calcification with marked thickening of the capsule. Finally, an appreciable number of adenomas of the thyroid, like adenomas elsewhere may undergo malignant degeneration (adenocarcinoma).

A different view of the etiology of thyroidal adenomas is that of Graham who presented a comprehensive paper on the relation of nodular goiter to neoplasia before the American Association for the Study of Goiter in 1929. In contrast to Woelfler's theory is that which ascribes the development of nodular goiters to a process of irregular hyperplasia and involution of the acinar cell. Graham believes that this idea is less speculative than the theory of origin from embryonal rests. The adult thyroidal epithelium involutes or reverts ("de-differentiates") to such a degree that it resembles the thyroid of a fetus. In brief, it assumes an embryonal character. Whatever the origin, whether from Woelfler's embryonal rests or by a process of "de-differentiation" (Graham)<sup>2</sup> of the acinar cell, basic changes must occur in the original tissue before neoplasia results.

The adenomas per se are responsible for the hyperthyroidism. They secrete a toxin which, if not actually chemically pure thyroxin, bears a close relationship to it. As the adenomas grow and develop, they elaborate increasing amounts of secretion and cause varying degrees of hyperthyroidism, mild to moderate or severe. The reason for the development of an adenoma from the dormant interstitial cells is not apparent. However, certain predisposing or exciting causes are recognized. First in importance is pregnancy which unquestionably bears a very close relationship to their development and which we shall consider in detail later under the heading, "Hyperthyroidism and Pregnancy."

During puberty and the menopause, certain endocrine disturbances involving the ovarian, thyroid and adrenal functions undoubtedly play a part in precipitating the appearance of adenomas.

Adenoma rarely occurs before puberty but is not uncommon in the postpuberty period. It is frequently seen during the menopause. Focal infection has been suggested as a factor in the etiology. It is

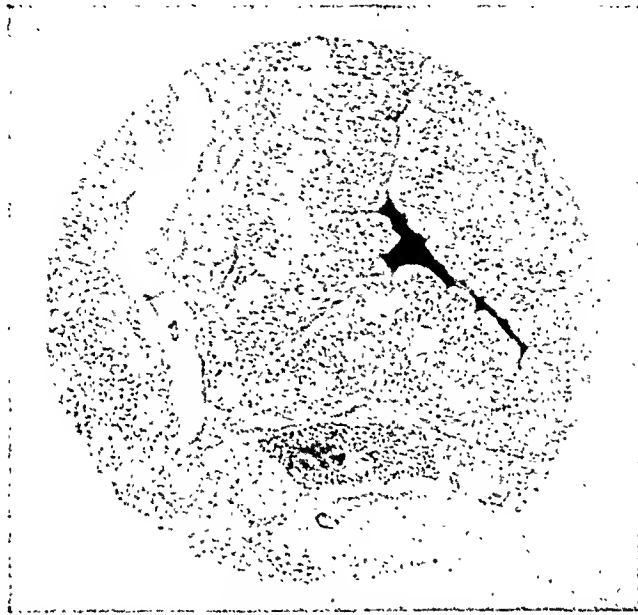


FIG. 3. Section of active hyperplasia—exophthalmic goiter—showing great numbers of mitochondria.

difficult to understand how an infection—focal or otherwise—could have any influence in the production of neoplastic disease. Furthermore, eradication of the foci is without benefit on the progress of the lesions. On the contrary, operative measures, such as tonsillectomy or the draining of sinus infections, invariably exacerbate the hyperthyroidism.

The number of adenomas that may be present in a single thyroid varies greatly from a solitary tumor to several hundred nodules. Likewise there is a great variability in the symptoms dependent upon the structure and cellular activity of the tumors. The recent young, more active nodules produce the most striking symptoms while the colloid and degenerative types produce less definite and active symptoms.

Since adenomas at their inception are microscopic in size, they may grow and enlarge considerably before they are suspected or discovered. Obviously then, a patient may show symptoms of hyperthyroidism long before palpable nodules are present. By careful staining methods (Goetsch)<sup>3</sup> it has been shown that toxic adenomas contain an abundance of structures called mitochondria which are

granular or rod-like in appearance. They have a great affinity for acid fuchsin which gives them a brilliant red color, and they are indices of protoplasmic activity. Accordingly large numbers of



FIG. 4. F. M., age 23. Discrete nodule (adenoma) in right lobe. Mild hyperthyroidism.

mitochondria are found in the thyroid cell in the severer grades of hyperthyroidism. (Fig. 3.)

*Signs and Symptoms.* In early cases, the patient may appear to be somewhat thin and sallow and possibly mildly underweight. The hands and feet are usually cold and clammy and there is ordinarily a tremor of the extended fingers. As the disease progresses, chronic fatigue and weakness become prominent symptoms. The spirit is willing but the strength is lacking. Emotionalism, crying spells without real provocation, hypersensitivity, depressions, moods and even melancholia may supervene. Lack of concentration and forgetfulness are quite common. Other symptoms are dispositional change such as irritability and flights of temper. Many patients complain of inward nervousness, a bizarre feeling of heaviness or uneasiness about the heart among other peculiar neurotic "inward" symptoms. Lability of the pulse rate is a rather characteristic finding. Sooner or later changes in the thyroid can be demonstrated. Careful palpation may

at first reveal the presence of a tiny nodule in the thyroid long before any visible enlargement is noticed. The small, early nodule is usually tender to palpation. This characteristic tenderness is of especial significance in demonstrating the incipient nodule particularly in the borderline or obscure case. As the nodule enlarges and especially when additional nodules are discovered, the hyperthyroidism is increased. The gland enlarges and unlike hyperplastic goiter loses its normal symmetry. (Fig. 4.)

#### CARDIAC SYMPTOMS—THE ROLE OF THE THYROID HORMONE

Continuous hyperthyroidism whether due to hyperplasia or adenoma leads to progressive myocardial insufficiency. In exophthalmic goiter, the toxemia is usually more severe and serious cardiac damage with incapacitation results earlier than in adenoma in which toxemia is usually less marked but more prolonged. However, eventually the cardiac damage and incapacitation may be quite as severe. This may in part be due to the average greater age of patients with adenoma.

Following the initial tachycardia, the ensuing cardiac signs and symptoms of dyspnea, irregularities in the pulse rate and extra systoles are followed by auricular fibrillation and occasionally by flutter. As the hyperthyroidism continues, the preceding symptoms are accentuated and a train of events leading to so-called "goiter heart" develops. The first indication of threatened cardiac incompetency is the presence of a few scattered and inconstant basal râles. Signs of incompetency such as an early ankle and shin edema gradually appear. At first the edema vanishes after a night's rest. Gradually the edema progresses upward along the legs and thighs. Abdominal ascites, pleural and pericardial effusion, cardiac dilatation and hypertrophy supervene and may terminate in general anasarca and death from cardiac failure.

During the progress of the preceding symptoms, significant rises in the blood pressure take place. In the early stages, the blood pressure rises only slightly if at all and a wide pulse pressure is maintained. As time elapses the blood pressure gradually climbs, arteriosclerotic changes in the blood vessels appear and unless the hyperthyroidism is relieved by operation, a permanent hypertension with a lowered pulse pressure may result and remain permanently whether operation is performed or not.

A considerable group of thyroid patients is one in which the hyperthyroidism is masked and in which a provisional diagnosis of

organic cardiac disease is made. We refer to a group of middle-aged patients who are obviously not suffering from Graves' disease but who have been suffering over long periods of time, possibly years, from chronic, mild, unrecognized hyperthyroidism due to adenomas that escaped detection and in whom the hyperthyroidism is overshadowed by the predominant cardiac symptoms. Too often they are treated as primary cardiacs and little if any attention is paid to the thyroid. Digitalis, rest and supportive treatment fail to correct the condition. Unless a careful history revealing thyroid symptoms and signs and the discovery on careful repeated search of one or more nodules in the thyroid indicate the true condition, such diagnostic aids as the electrocardiogram and the basal metabolic rate are of questionable aid. Patients suffering from primary, organic, cardiac disease besides showing electrocardiographic evidences of myocardial degeneration may, like the hyperthyroid patient, also have elevated basal metabolism. It follows that in every elderly patient showing tachycardia, cardiac irregularity or evidences of failing compensation of obscure origin, we should be on constant watch for evidences of hyperthyroidism. In exceptional cases the x-ray may reveal the presence of a substernal goiter.

The importance of the recognition of hyperthyroidism superimposed on a heart that is already damaged by rheumatic disease and hypertension can hardly be overemphasized. The hyperthyroidism accompanying such conditions may be the prime factor in causing the heart to become incompetent. Early operation may once again render the heart competent.

Although the association of proven coronary disease with hyperthyroidism is in our experience rather rare, anginal attacks are by no means infrequent. Occasionally, a patient may give a story of severe cardiac or substernal pain which radiates to the shoulder and even into the forearm. However, electrocardiographic tracings fail to establish coronary disease and operation is followed by disappearance of the symptoms. Various hypotheses have been advanced to explain cardiac pain and anginal attacks in the thyrocardiac. None of them is entirely satisfactory. It has been suggested that dilatation and hypertrophy of the heart leads to ischemia of the heart musculature from stretching of the nutrient coronary vessels. Pain is said to be the result of the ischemia.

It has long been appreciated both clinically and experimentally that the heart action is peculiarly sensitive and responsive to the toxemia of hyperthyroidism. The exact mechanism of the production

of cardiac damage is not entirely clear. It is widely held that the myocardium is peculiarly sensitive and vulnerable to the thyroid hormone and that the cardiac manifestations result from the specific, destructive action of the thyroid toxin on the myocardium per se. However, in patients dying in the terminal phases of hyperthyroidism or from crisis, the heart muscle does not show any definite structural changes referable to a specific toxin. There are no characteristic basic findings that differentiate the heart of the patient succumbing to hyperthyroidism from one dying of cardiac failure from other commonly recognized causes.

Another view attributes the cardiac damage to accelerated circulation caused by increased metabolism and the need for increased amounts of oxygen. The heart is overworked and eventually becomes exhausted in its struggle against the continuous overloading in consequence of the elevated metabolism. In this connection, it may be mentioned that an appreciable number of unrecognized and obscure cases of goiter present cardiac arrhythmias and other evidences of cardiac damage as the first prominent symptoms. Over long periods of time, even years, there may have been absence of heart consciousness. The pulse and metabolic rates may have remained within normal limits, the weight may not have varied greatly and the characteristic symptoms of hyperthyroidism may have been minimal and thus escaped notice. It would seem logical to attribute the myocardial effects in these cases to a specific destructive action of the long continued, though mild, toxemia rather than to overwork. The rapid improvement in cardiac function that almost invariably follows successful thyroidectomy would seem to fortify this belief. Hearts damaged from causes other than hyperthyroidism are prone to remain damaged. The lowering of the glycogen content of the myocardium in hyperthyroidism is said to further predispose the myocardium to damage. Moreover, some observers attribute the tachycardia and other cardiac manifestations to stimulation of the sympathetic nervous system by the thyroid hormone. It is very probable that the cause of the myocardial damage is to be sought not in one but rather in a combination of several factors. Whatever the mechanism, the surgeon's objective is to eliminate the thyrotoxicosis by adequate thyroid resection. This remains the best, in fact the only means of restoring cardiac function.

From the foregoing, it is clear that hyperthyroidism regardless of its etiology produces a large number of characteristic general



signs and symptoms. Some authors regard hyperplastic goiter and toxic adenoma as identical. We feel, however, that in matters of origin, symptomatology and fundamental pathology there are a sufficient number of differential points to classify as separate entities. These are contrasted in the following outline:

#### EXOPHTHALMIC GOITER

The disease develops rapidly and continues at a quick tempo.

It is not uncommon under twenty years of age.

There is a diffuse, uniform enlargement of the thyroid. Normal symmetry is preserved. The gland is smooth, rubbery and resilient in consistency.

There is generally rapid development of the symptoms. Tremor is marked and may extend to the forearm and even to the entire body. The nervous symptoms particularly the objective ones are pronounced. Restlessness is severe. Mental manifestations bordering on psychosis are not infrequent.

The appetite is greatly increased. Loss of weight may be rapid and extreme. Vomiting and diarrhea are frequent. Acidosis and crises occur oftener.

Vasomotor instability, increased perspiration, flushing and heat intolerance are common.

Pressure symptoms and mechanical factors are absent. The voice is not impaired. The goiter does not invade the mediastinum.

The pulse is generally higher—commonly 120 to 140. The pulse pressure is moderately increased.

#### ADENOMA

The symptoms develop insidiously and advance more slowly.

It is relatively uncommon before twenty years of age.

There is greater variation in the size of the gland. Single or multiple nodules of varying size and consistency are present and the normal symmetry is consequently lost.

Symptoms develop more slowly. Tremor though present is less pronounced. Symptoms are milder and not as easily elicited. Restlessness is less obvious. Mental symptoms, while fairly frequent, are longer delayed.

The appetite is more variable. The loss of weight is usually less rapid and extensive. Vomiting and diarrhea are less frequent. Acidosis and crises are not as common.

These symptoms are less pronounced. Heat intolerance is less marked.

Pressure symptoms, deviation and constriction of the trachea are frequent. The voice may become husky from pressure on the recurrent nerve. A dry cough is common. Mediastinal encroachment is not unusual.

The pulse is generally lower—commonly 90 to 110. The pulse pressure is greatly increased. Arhy-

## EXOPHTHALMIC GOITER

Arrhythmias and fibrillation are fairly frequent.

A characteristic "drive" may be present.

Ocular signs are characteristic. Thrills and bruits are commonly present.

The basal metabolic rates are generally higher.

The patient is more rapidly incapacitated.

Malignancy is rarely if ever encountered.

## ADENOMA

Arrhythmias and fibrillation are more frequent.

Chronic fatigue is more frequent.

Ocular and vascular signs are uniformly and characteristically absent.

The basal metabolic rates are more variable and tend to be lower.

Incapacitation takes place less rapidly.

Malignant degeneration occurs in 3 to 4 per cent of cases.

## DIFFERENTIAL DIAGNOSIS

While frank hyperthyroidism is usually recognized easily, there are certain conditions which may be confused with early hyperthyroidism.

*Tuberculosis.* Among the most important is tuberculosis. The familiar findings of fatigue, asthenia, lability of pulse rate, weakness, mild nervousness and vasomotor instability with increased perspiration might lead one to confuse early hyperthyroidism with incipient tuberculosis. The findings in the thyroid may not be convincing and a careful history, physical examination and x-ray studies may fail to differentiate the two. In a fair number of cases, the hyperthyroid patient may be detected from one suffering from incipient pulmonary tuberculosis by her constitutional response to adrenalin. (Goetsch).<sup>4</sup>

*Sympathicotonia.* The so-called sympathicotonic type of functional neurosis presents many signs and symptoms which overlap into the field of true hyperthyroidism. The syndrome is characterized by a highly sensitive nervous system. The common findings are a highly nervous state, asthenia, vasomotor instability, tachycardia, increased perspiration, tremor and mild emotionalism. The tachycardia is especially marked when the patient is under emotional strain and there is consequently great lability of the pulse rate. Frequently, phobias such as fears of fainting, of collapsing in the street or inability to take care of oneself unless accompanied by another person are superimposed. The symptoms may simulate

an anxiety neurosis and are generally of bad prognostic significance and very difficult to treat and eliminate.

The sympathicotonic individual can usually be differentiated from the true hyperthyroid by the fact that the nervousness is familial and has been present as a rule as long as the patient can remember, whereas in hyperthyroidism the complaint usually but not invariably has a definite beginning. Furthermore the complaint of the neurasthenic and sympathicotonic patient is rambling and bizarre; it keeps changing and becomes more and more involved. The true hyperthyroid patient on the contrary is noted for the consistency of his story.

The differential findings in the thyroid gland assume compelling significance in culling the neuroses from the hyperthyroid states. The gland is rarely enlarged in the neurasthenic and there are no findings such as nodules or increased circulation, whereas it is the exception to find real and definite hyperthyroidism unassociated with either some glandular enlargement, the presence of one or more nodules or evidences of increased vascularity. The basal metabolic rate in the neuroses is commonly normal or even below normal, whereas in hyperthyroidism the rate is usually but not necessarily elevated in proportion to the degree of the hyperthyroidism.

*Neurocirculatory Asthenia—Pseudo-Graves' Syndrome.* Patients suffering from so-called neurocirculatory asthenia present difficulties in the differential diagnosis. These individuals are sympathicotonic by nature. As children, they are delicate. They lack physical strength and hence do not choose strenuous occupations. They lack ambition and generally feel inferior. The common symptoms are palpitation, increased perspiration and extreme fatigue. Tremor and dermatographism are characteristically present. Very occasionally a sympathicotonic patient may show, in addition to the previously enumerated symptoms, some brightness and even an increased prominence of the eyes, and the thyroid though not enlarged may present minor but definite thrills and bruits such as one finds in Graves' disease. Briefly, the patient looks like one suffering from an early exophthalmic goiter. A number of terms have been applied by various authors—autonomic imbalance, pseudo-Graves' syndrome, effort syndrome and irritable heart. The important characteristics are the absence of an enlarged thyroid and the consistently normal metabolism. The condition is difficult to remedy and surgical attack on the thyroid should be scrupulously avoided.

It is apparent that the separation of the neuroses from true hyperthyroidism cannot be done quickly and with unfailing accuracy. The diagnostic aids are limited and give us little real help in differentiating the truly hyperthyroid patient for whom surgery is indicated and curative from the functional neurotic for whom surgery is contraindicated and harmful. It should be stressed that when a border-line case is suspected of hyperthyroidism, nothing can be lost by a period of waiting and observation at intervals. Since hyperthyroidism is a progressive disease, time will reveal the true character of the complaint and permit the development of objective diagnostic findings in the thyroid. Useless operations will be avoided. A therapeutic test will occasionally be helpful especially in dealing with suspected hyperplasia. Lugol's solution may be given in routine fashion for a week. If the patient is a neurotic, no harm will be done; and if she is suffering from hyperthyroidism, a favorable response may indicate the advisability of operative treatment.

#### PRESSURE EFFECTS OF GOITER

In the matter of mechanical effects, we need consider practically only the adenomatous goiter. Hyperplastic goiter—whether a mild hyperplasia or exophthalmic goiter—rarely causes any serious mechanical embarrassment. The pathology involves the gland as a whole rather than any particular part. Consequently, the enlargement extends in all directions, symmetry is maintained and the goiter even when large does not extend downwards into the mediastinum. Hence, serious mechanical difficulties involving tracheal displacement or narrowing rarely if ever occur, and respiratory embarrassment such as suffocation and stridor are practically never encountered. Very occasionally a moderately large hyperplastic goiter, particularly if it is present in a short stout neck, may be engaging the thoracic inlet too snugly causing some distention of the superficial veins of the neck leading to a sense of fulness and pressure in the head or an occasional headache. In general, we need not worry about serious mechanical difficulties provided we realize that we are dealing with a hyperplastic goiter.

With adenoma, however, the problem is entirely different. A large adenomatous goiter even though it maintains a cervical position may lead to troublesome and serious mechanical difficulties. Thus a large tumor of either the left or the right lobe may so displace

the trachea because the other side that the tracheal diameter is greatly narrowed at the point of impingement. The patient complains of dyspnea, which often is limited to a period of inspiration.



FIG. 10. Enlarged thyroids compressing trachea with resultant pressure effects on trachea and epiglottis.

infection should supervene, severe dyspnea may result. In fact, the congested tracheal mucosa incidental to respiratory infection may so compromise the already diminished lumen that acute suffocation requiring emergency measures may supervene. The preceding condition may be further aggravated if a large adenomatous mass on one side opposes a small, firm nodule on the other side. This is particularly true if the smaller mass is firm and hard enough to cause pressure softening of one or more tracheal rings.

The most frequent cause of serious pressure symptoms is the goiter that has become partly or entirely intrathoracic. The most common is that due to an adenomatous nodule at one or the other of the lower poles or in the isthmus. Gradually through gravity and enlargement it may descend beneath the clavicle or sternum into the mediastinum. To begin with, the nodule is extrathoracic in position. It may in time be alternatingly aspirated into and expelled



FIG. 6. M. B., age 42. A, huge adenomatous goiter with tracheal displacement and pressure effects. B, x-ray film showing marked displacement of the trachea. C, excised tumor of left lobe.

from the mediastinum by deep inspirations and pressure of the cervical musculature resulting in the condition called wandering goiter. Serious difficulties may not arise until it attains such a size



FIG. 6. For descriptive legend see opposite page.

that expulsion can no longer take place. Gradually increasing dyspnea or suffocation may supervene since the more the goiter enlarges the more it is restricted by the unyielding thorax. If perchance the intrathoracic goiter should be bilateral, pressure is exerted in two directions and a scabbard trachea results. In addition to direct mechanical effects on the trachea per se, prolonged pressure on one or the other recurrent nerves may result in abductor paresis producing hoarseness and adding further to the respiratory distress. Finally, pressure on the jugular veins may so interfere with the venous return that the superficial veins are rendered prominent from engorgement, producing eventually the caput medusae so typical of large retrosternal intrathoracic goiter. This venous phenomenon represents a compensatory mechanism on the part of the veins of the neck and upper thoracic region. (Fig. 5.)

For the most part, an intrathoracic goiter is only partly so. More often the tumor is both cervical and retrosternal or subcla-

vicular in position and the upper limits can be palpated particularly when the patient swallows or is made to cough forcibly. In the comparatively rare condition in which the goiter is completely intrathoracic, no portion rises into the cervical region under any conditions and its pedicle or connection with the thyroid proper may easily escape detection.

Whenever on the basis of the foregoing signs and symptoms, substernal or intrathoracic goiter is suspected, one should look for evidences of hyperthyroidism in the history and physical examination. Percussion may reveal more or less retrosternal dullness over the mass. Finally, the x-ray is of invaluable help. An anteroposterior view should be taken. This will reveal any lateral displacement or constriction and shape of the trachea, whether S-shaped, spiral or otherwise. Since a substernal goiter arising from the isthmus may retain a median position, a lateral x-ray view will usually disclose whether there is narrowing or compression of the trachea in the anteroposterior diameter or whether the goiter has insinuated itself between the trachea and the esophagus.

Occasionally, particularly with a relatively non-toxic, intrathoracic, adenomatous goiter that has produced little if any hyperthyroidism, the differential diagnosis of goiter and mediastinal neoplasm such as teratoma or thymoma becomes difficult. However, an adenoma tends to maintain its smooth discrete outline. Other tumors are usually less discrete. Fluoroscopy is of invaluable aid. It may establish the diagnosis in doubtful cases since practically all intrathoracic goiters maintain connection with the thyroid and hence tend to move upward on swallowing as distinct from most other mediastinal tumors which tend to remain fixed. (Fig. 6A, B and C.)

#### TESTS FOR HYPERTHYROIDISM

A few clinical laboratory findings are helpful in diagnosis. In active hyperthyroidism there is an actual and a relative increase in the mononuclear leucocytes. They may reach 60 to 70 per cent or the total count. With this increase in the mononuclear count, there is a corresponding decrease in the polymorphonuclear cells to 35 of 40 per cent of the total. These findings were first pointed out by Kocher who was led to attach considerable prognostic value to the degree of lymphocytosis. The higher counts indicated to him the less favorable cases of hyperthyroidism.



*Blood Sugar Level.* A relative diminution in the sugar content of the blood is commonly observed in hyperactive cases and varies with the degree of the hyperthyroidism. In severe cases the sugar level may fall to 100 or even 80 mg. of sugar per 100 c.c. of blood.

*Blood Cholesterol.* In general the blood cholesterol varies inversely with the extent of the hyperthyroidism and directly with the degree of the hypothyroidism. However, the inverse relationship is not constant and the cholesterol determination, therefore, has been only of passing significance as a diagnostic aid.

*Urinary Findings.* There are no characteristic changes in the urine until late degenerative effects in the cardiovascular-renal system are produced. In some extremely active cases, glycosuria may occur as a result of the rapid mobilization of glucose in the body with resultant overflow in the urine. It occurs oftenest in the severe hyperplasias and usually disappears after operation. It must be differentiated from true diabetes, in which the administration of glucose is followed by a rapid rise and a relatively slow fall in the blood sugar level, whereas in hyperthyroidism the blood sugar under similar conditions also rises but is less sustained than in diabetes.

*Basal Metabolism.* In addition to information gained from the history, symptoms and physical signs, certain tests are helpful in the detection of hyperthyroidism and hypothyroidism. Friedrich von Müller and Magnus-Levy were the first to point out that an increase in general metabolism is one of the most significant features of hyperthyroidism and that a decrease in the metabolism is characteristic of hypothyroidism. von Müller discovered that his patients with exophthalmic goiter not only consumed more food than was required to meet their caloric needs, but that they were excreting more nitrogen than they were receiving in their food. The patients were actually in a condition of relative inanition notwithstanding that they were consuming far more food than normal persons of the same age and weight. These facts were interpreted as due to a regulatory action of the thyroid hormone on the fundamental metabolic processes.

Very soon after these discoveries, attempts were made to measure the heat production and basal metabolism in patients under various conditions of health and disease. By the term "basal metabolic rate" of an organism we mean the minimal heat production of that organism measured from 12 to 18 hours after the inges-

tion of food under complete rest. It is not within the scope of this paper to go into the various details of determining the basal metabolic rate since devices for its estimation have been in use for many years in all well-conducted hospitals. We shall rather content ourselves with a consideration of its application to clinical practice.

The basal metabolic rate when accurately determined is of great value in the diagnosis and treatment of thyroid disorders.<sup>5</sup> However, it is not an infallible index and should never be the only guide in estimating the degree of overactivity. Zuntz was the first to realize the importance of absolute muscular repose in determining the true basal metabolism and Magnus-Levy showed the influence of various factors such as age, sex, weight, excitement, menstruation and pregnancy. In general it is accepted that the level of the basal metabolism is a valuable guide in judging the degree of the hyperthyroidism. This supposition must, however, not be accepted without reserve especially when only a single rate has been determined. First of all, there is always the danger of error through leakage and faulty technic. Also one must be on the alert for conditions such as fevers, tuberculosis, diabetes, various anemias and pituitary disorders which tend to increase metabolism.

In cases of adenoma the basal metabolic rate is helpful in estimating the degree of the toxemia and in general it parallels the clinical activity. However, we should bear in mind that chronic toxemia in long standing cases may have damaged the nervous system, heart and kidneys to such an extent that the metabolic activity may be depressed to a relatively normal or even subnormal level. A favorable rate might, therefore, be a poor criterion of the patient's ability to withstand operation. A careful evaluation of the history and the physical status of the patient are of relatively greater importance.

In numerous cases of adenoma, the symptoms are for the most part subjective in character and difficult to elicit. There may be absence of tremor and objective nervousness and the basal metabolic rates may well be within normal limits or actually below normal. Excepting for the presence of one or more nodules in the thyroid, one would be prone to dismiss such patients as free from hyperthyroidism. Provided there are no clinical evidences of hypothyroidism, we have not been deterred from giving such patients the benefits of operation and have invariably noticed that operation is followed by

a prompt cessation of the subjective nervousness and a general feeling of well-being. Incidentally following operation, depressed metabolic rates tend to rise due in all likelihood to a rehabilitation of the normal thyroid elements after pressure and possibly other inhibiting effects of the adenoma have been removed. A basal metabolic rate may thus indicate that the oxidative processes may be normal without, however, indicating other altered functions or dysthyroidism that can be relieved by operation. This brings to mind the terms "toxic" and "non-toxic" adenoma. It is abundantly clear from the literature and discussions among physicians that these terms mean different things to different people. To some the word "toxic" is associated with increased metabolism only, while to others it signifies the presence of symptoms. It is obvious that a great deal of confusion may result and that certain patients with toxic adenomas as judged from the symptoms and signs might be denied the benefits of operative treatment, if one were to wait for increased metabolism to establish the diagnosis.

It is in the cases of hyperthyroidism due to the higher grades of hyperplasia as found in exophthalmic goiter that the basal metabolic rate is especially helpful. The basal metabolic rate in exophthalmic goiter as with active adenoma commonly parallels the degree of the hyperthyroidism. In general, but particularly in recent and acute cases, the higher the rate, the greater the hyperthyroidism. However, one cannot be arbitrary in setting a definite level beyond which the basal metabolic rate indicates a danger of severe post-operative hyperthyroidism. Nevertheless, when the history and the clinical status of the patient indicate a severe thyroid toxemia, a high basal metabolic rate in excess of +50 or +60 per cent should tend to make the surgeon cautious, lest by too extensive an operation he bring about a critical reaction or possible fatality. Preliminary ligations or stage operations may become necessary.

In chronic hyperthyroidism with marked emaciation, one should realize the influence of poor nutrition in depressing heat production. While the basal metabolic rate may give us an index of the amount of combustion that is taking place, it does not give us a clue to the amount of degeneration that may have taken place in the cardiovascular system, the kidneys, nervous system and other organs which so largely determine the patient's ability to withstand operative procedures. Therefore, in cases of long standing hyperthyroidism with severe cardiac damage, a favorable metabolic rate may mis-

lead the surgeon into attempting too extensive an operation and courting an unexpected fatality.

It is obvious that the basal metabolic rate can in no manner replace the necessity for detailed clinical study of the individual case, that a normal rate does not exclude hyperthyroidism and that an elevated rate by no means always indicates hyperthyroidism. Due regard must always be had for the clinical picture and when this necessity is more generally appreciated, physicians will be less prone to demand routine basal metabolic rate determinations as the all-important considerations.

#### ACIDOSIS—THE ROLE OF CARBOHYDRATE METABOLISM

It is a rather frequent experience among thyroid surgeons that a more or less serious acidosis is prone to occur in the early postoperative period especially when dealing with the higher grades of hyperthyroidism. The acidosis manifests itself clinically by a number of annoying symptoms such as extreme nervousness and restlessness, nausea and vomiting, headache, diarrhea, dry, parched tongue, acetone odor to the breath and acetone bodies in the urine. When these symptoms and findings are superimposed upon those due more directly to the hyperthyroidism such as severe tachycardia and a rising temperature, the surgeon is confronted with a syndrome fraught with great anxiety and very distressing to the patient.

The relationship of the thyroid to carbohydrate metabolism offers a probable clue to the etiology of the disturbing acidosis, since of the ductless glands the thyroid and adrenals are probably the most directly involved in disturbances of carbohydrate metabolism. Thus, for example Kuriyama discovered that the feeding of thyroid extract to white rats produced a diminished glycogen content of the liver. There are other facts indicating that excessive thyroid secretion and adrenalin mobilize glycogen and produce thereby an increased sugar content in the blood provided, of course, that there is a sufficient glycogen reserve. Moreover, prolonged hyperthyroidism causes a marked loss of body weight and an accompanying lowering of the glycogen reserve. It is our experience that acidosis is prone to occur particularly after operation as a result of this depletion.

Previous to 1922 in our search for an explanation for the postoperative reactions, some interesting and we believe enlightening investigations were made at our Clinic (Goetsch and Browder)<sup>6</sup> on

the sugar content of the blood of patients with varying degrees of hyperthyroidism as contrasted with those of normal controls. Since the thyroid is so intimately bound up with metabolism, we should expect varying degrees of disturbances in the metabolism proportionate to the amount of thyroid hormone in the circulation. First we studied the behavior of the blood sugar before, during and following operation. It was demonstrated that there is an early, rather definite rise of blood sugar as a normal response to the factors encountered in the operation such as anesthesia, trauma, and emotional disturbances whether in the hyperthyroid or the normal patient. The only significant difference noticed was the fact that in the normal control individual, the blood sugar rises gradually and over a longer period and only gradually falls to the normal level in two to three or more days, whereas in the hyperthyroid individual, the initial rise in blood sugar is more abrupt, is not so high and then falls promptly to the preoperative level or lower, often in one-half hour or less. It was found that in the more severe grades of hyperthyroidism, the hyperglycemic curve does not reach as high a level and falls even more rapidly, suggesting that in the very active cases there is a correspondingly greater depletion of the glycogen reserve and a diminished response to the factors calling forth glucose.

An interesting relationship between the degrees of hyperglycemia and the acetoneuria and acidosis seemed to be present. Thus in those cases of marked hyperthyroidism in which the blood sugar curve was low and tended to fall promptly to normal or lower, the acidosis was correspondingly more severe. This suggested that when the glycogen reserve is low, the defense factors against acidosis are lacking and lead to the development of clinical symptoms and acetoneuria. Conversely, when the blood sugar curve remained high and sustained following operation, only slight or no evidences of acetone or acidosis occurred. Therefore, there may well be a relationship between the sugar content of the blood and the appearance of acidosis. Indeed, our studies seemed to indicate that the higher the degree of hyperthyroidism, the less the hyperglycemia and the greater the likelihood of acidosis following operation. It seems probable, too, that when there is a liberal carbohydrate reserve in the form of glycogen, fats and proteins are spared while the glycogen is consumed and acidosis consequently minimized or prevented.

The foregoing considerations confirm on physiological grounds what has long been appreciated clinically, namely, that carbo-

hydrates play a major role in the physiology of the hyperthyroid patient. In preparation for operation, a liberal carbohydrate diet is very helpful in fortifying the glycogen reserve. Moreover, intravenous glucose injections are almost specific in the control of acidosis before and following operations on the thyroid.

**Crisis.** While it may be said that the physiology of the thyroid is as well understood as that of any endocrine, there is much regarding the pathological physiology of the thyroid that still remains in the realm of the speculative. This is particularly true of a curious and fulminating phenomenon known as thyroid crisis or storm, which occasionally develops spontaneously in the course of severe hyperthyroidism and which is still a major factor in deaths from hyperthyroidism. Fortunately in the numerous cases of hyperthyroidism that are observed and treated in a busy thyroid clinic, this ominous development is relatively infrequent. Unfortunately, however, the signals indicating impending storm are few and not clearly drawn. Certain facts and circumstances are, however, indicative. Predisposing factors to crisis in the course of a progressive hyperthyroidism are marked accentuation of mental states such as the emotions of fear, anger, worry and extreme anxiety. When these are coupled with a constantly and rapidly increasing rise in the metabolic and pulse rates, marked loss of weight, various phobias, mental deterioration and particularly nausea and vomiting, one should be especially vigilant with regard to a lurking crisis.

When crisis is impending, one notices a sudden accentuation of the physical, mental and nervous states of the patient. The general restlessness, the pulse rate and the temperature increase rapidly. In short the picture presented is one of an alarming exaggeration of all of the patient's previous signs of hyperthyroidism. His appearance indicates a condition of profound toxemia. Something seems to be eating at his very vitals and one gathers that a poison of unusual virulence is destroying him. Not infrequently, evidences of acidosis with acetone in the urine, acetone breath, severe vomiting and diarrhea add to the gravity of the picture. However, urinary findings may be singularly absent. As the objective findings—pulse, temperature and respirations—increase with alarming rapidity, the mental alertness and physical restlessness are maintained and may even be heightened until such time as an ominous mental dullness and general inertia and apathy indicate an impending dissolution. Unless the rapid march of events is halted, the patient lapses into delirium,

semi-consciousness, and cyanosis and dies in a state of hyperpyrexia ( $105$  to  $108^{\circ}\text{F.}$ ) and coma with a corresponding increase in both the pulse and respiratory rates.

Thyroid storm or crisis as described may also follow operations on the thyroid with similar critical developments. Postoperatively as preoperatively the warning signals may be indefinite and inconstant but just as we recognize certain predisposing causes in the spontaneous development of crisis or thyroid storm, we recognize certain dangers in the patient who has been submitted to surgical treatment. Extreme toxicity, unusually high metabolic rates, marked emaciation and mental deterioration are predisposing factors. The incorrect use of iodine in the medical treatment, particularly if given over prolonged periods, seems to predispose in a large percentage of cases. Moreover, patients who in spite of the standardized preliminary treatment with iodine fail to improve noticeably and who, following the preoperative iodination maintain a high degree of hyperthyroidism with little if any drop in the metabolic and pulse rates, seem particularly liable to develop crisis. Then again the basal metabolic rate is no real criterion since crisis may occasionally follow operations on patients with relatively low metabolic rates as for example in those with long-standing, chronic adenomatous goiters. While stage operations undoubtedly tend to diminish the incidence of crisis, the type and extent of operation by no means always determines the likelihood of the development or absence of crisis. Deaths from crisis may occur after minimal procedures such as the ligation of a single, superior thyroid artery. On the other hand so-called bad-risk patients frequently go through extensive operations without untoward postoperative reactions.

The interrelationships of the sympathetic nervous system, adrenals and the thyroid have long been emphasized by Crile and studies have been made in our clinic which showed that the characteristic postoperative reactions such as restlessness, hyperpyrexia, tachycardia and other features of a severe reaction can be reproduced by the subcutaneous injections of adrenalin (Goetsch & Ritzmann).<sup>7</sup> Moreover pulmonary edema and tracheitis similar to that encountered in crisis may be caused in experimental animals by injection of adrenalin. It seems entirely probable, therefore, that crisis may in part at least be an expression of adrenal hyperactivity.

In a certain number of cases of postoperative crisis, jaundice and other manifestations of disturbed hepatic function have been noted

clinically and varying amounts of fatty degeneration, focal necrosis and hepatitis have been found at autopsy. The severe toxemia doubtless plays an important part in their production. Indeed, some authors have advanced the theory that death in crisis results in the main from hepatic insufficiency. While no constant cardiac lesions characteristic of crisis have been described, it is abundantly evident to anyone who has witnessed the course of a typical crisis that the heart is struggling against almost insuperable odds under tremendous strain. Indeed, the matter of life or death in thyroid crisis seems to be dependent upon the ability of the heart to hold out against an overwhelming toxemia.

#### HYPERTHYROIDISM AND PREGNANCY

Since there is a distinct interrelationship between certain of the endocrine glands, it is not surprising that hyperthyroidism and pregnancy should influence each other. Incidentally we know that atrophy and destruction of the pituitary gland results in amenorrhea and sterility. Similarly partial removal of the gland in young animals results in failure of sex development with absence of ovulation and resultant sterility. Since it has long been observed that in pregnancy there is a physiological activation and increased metabolism of the body tissues generally and a heightened activity of the endocrine glands in particular, it follows that patients during pregnancy might present symptoms of increased thyroid activity such as tremor, nervousness, tachycardia and mild emotionalism. The thyroid gland enlarges not only during pregnancy but also during menstrual periods at which time symptoms of irritability, vasomotor instability, tachycardia and tremor are rather common.

In the routine of history taking, we frequently hear that the patient was perfectly well till her first pregnancy during the course of which she developed definite evidences and symptoms of hyperthyroidism that progressed after delivery and led directly into one of the frank types of thyroid pathology such as exophthalmic goiter. Furthermore, the history might indicate that with each succeeding pregnancy, a progressive increase in the hyperthyroidism occurred. Again, in the case of adenoma, a small lump was possibly first noticed during or after the first pregnancy or a pre-existing adenoma may have enlarged or become activated. The activity may have subsided during the puerperium only to be reestablished during subsequent pregnancies. These manifestations explain the "nervous



breakdowns" following repeated pregnancies. The story may repeat itself many times with a gradual increase in size of the original adenoma or the appearance of new nodules. Indeed in certain cases, the dictum "for every child a tooth" might well be paraphrased "for every child an adenoma."

Though pregnancy in the presence of a moderately active exophthalmic goiter is not an unusual occurrence it is rather uncommon in the course of severe exophthalmic goiter. The thyroid toxemia seemingly has a very profound effect upon the pelvic organs. In the early stages, dysmenorrhea and menorrhagia are quite common, possibly as the result of a stimulating effect. In the extremely severe states, a destructive action takes place upon the ovarian and uterine functions resulting in failure of ovulation, long periods of amenorrhea and sterility. These are undoubtedly in the nature of a protective mechanism and indeed in certain instances may actually be life saving.

Because it is clear that pregnancy frequently brings a smoldering hyperthyroidism to light and usually exacerbates an existing one, the question arises: How shall we treat a patient that presents both pregnancy and hyperthyroidism? Previous to 1921, we had no rigid, firm convictions. There is a general notion among physicians that it is dangerous to allow pregnancy to proceed in the presence of hyperthyroidism both because of the possible danger of miscarriage and because of the exacerbating effect of the pregnancy on the hyperthyroidism. Consequently in the past, abortion has frequently been recommended.

In view of our experience since 1921, we are convinced that operation for the relief of hyperthyroidism is entirely feasible and safe particularly in the early months of pregnancy regardless of whether one is dealing with Graves' disease or active adenoma.<sup>8</sup> The patient is promptly relieved of her hyperthyroidism, the worry of both patient and physician regarding the later stages of pregnancy is relieved and normal delivery with a healthy baby is secured at term.

We do not wish to appear dogmatic and convey the impression that we are advising operation upon all patients with goiters complicated by pregnancy. Many of the patients with mild hyperplasias will develop slightly increased nervousness, a mild tremor and tachycardia. These symptoms are amenable to ordinary symptomatic and sedative treatment and hence the patient can be successfully carried through labor and the puerperium particularly if she is

not a primipara. However, when doubt exists especially in the face of increasing activity, the wisest course even in the milder cases would be to submit the patient to thyroidectomy.

When dealing with patients with nodular adenomatous goiters that are often degenerated or cystic and hence show little activity without great increase in the basal metabolic rate, we feel that the pregnancy has little, if any, bearing upon the relatively inactive tumor and operation should obviously be deferred to the puerperium. It is only the active, unmistakable cases of hyperthyroidism that give us concern.

Our early cases, especially those from 1929 to 1939 inclusive, were studied in conjunction with Dr. Alfred C. Beck in the Surgical and Obstetrical Divisions of the Long Island College Hospital. We consider the first four months of pregnancy as the most favorable time for operation since the placental attachment is said to be less firm after the fourth month. Formerly our anesthetic of choice was nitrous oxide-oxygen supplemented by small amounts of ether in order to minimize the danger to the gravid uterus of anoxemia from gas-oxygen alone. The thyroidectomy was carried out expeditiously under customary routine. Morphine was given fairly liberally following operation to prevent uterine contractions. Our results were uniformly satisfactory. The postoperative course was generally free from disturbing nausea and vomiting and devoid of any symptoms referable to the uterus and after twenty-four to forty-eight hours, convalescence was in every respect like that of the ordinary, non-pregnant, hyperthyroid patient.

After the fall of 1935, we replaced nitrous oxide-oxygen-ether by cyclopropane<sup>9</sup> as the anesthetic of choice in the surgery of the thyroid. Formerly there were certain objections to nitrous oxide—possibly theoretical—on the grounds that the unavoidable anoxemia predisposed to fetal asphyxia and abortion. While our results with nitrous oxide failed to bear out this supposed danger, we feel that cyclopropane has all the virtues and none of the disadvantages of nitrous oxide. The high oxygen concentration apparently dispels even the remotest danger of fetal asphyxiation and abortion.

Since 1921, we have taken a firm stand against abortion when pregnancy has complicated hyperthyroidism. We feel that emptying the uterus is generally more of an ordeal and fraught with more trauma and greater danger than an expeditious thyroidectomy. Besides, we are convinced that an induced abortion particularly in

the advanced case is a greater factor in stimulating an accompanying hyperthyroidism than pregnancy itself. After an adequate thyroidectomy, the hyperthyroidism is promptly eliminated and an exacerbation is obviously no longer possible. In an attempt to reduce the problem to rule, we would say that when the question of interruption presents itself, it is the hyperthyroidism and not the pregnancy that should be interrupted.

From 1929 to 1939 inclusive, we performed thyroidectomy for exophthalmic goiter complicated by pregnancy nine times—twice at two and one-half months, once at three months, twice at four months, twice at four and one-half months, once at five months and once at six and one-half months. In one instance in a four month's pregnancy there had been some mild spotting before operation. During the course in the hospital, the patient was observed carefully by the Department of Obstetrics and was delivered at term of a normal baby. The other patients—eight in number—were delivered of normal babies at term. Thyroidectomy was performed on two patients with adenoma complicated by pregnancy—one of two month's and one of three month's duration. The pregnancies eventuated in normal deliveries and normal babies.

We have no exact figures in the cases in which the patients with hyperthyroidism and pregnancy were treated conservatively and in which because of the mild hyperthyroidism, thyroidectomy was postponed to the puerperium. They doubtless were considerably in excess of eleven.

#### DIABETES AND HYPERTHYROIDISM

Disturbances of carbohydrate metabolism as mentioned are not uncommon in hyperthyroidism. It is, therefore, not surprising that transient glycosuria and hyperglycemia are occasionally noticed particularly in cases of marked severity. They commonly disappear when the hyperthyroidism is controlled. True diabetes on the other hand is relatively infrequent in association with hyperthyroidism. Thus in 4900 cases of hyperthyroidism treated surgically, there were only twenty-five instances of true diabetes—a ratio of 1:196. Of these twenty-five cases ranging in ages from 26 to 67, there were eleven cases of exophthalmic goiter and fourteen of adenoma. These data are at variance with the preponderance of hyperplastic goiter over adenoma reported from other sources. In all of our cases, the diabetes was adequately controlled by diet and insulin and the

prognosis with regard to care of the hyperthyroidism by operation was favorable. Moreover, carbohydrate tolerance was improved following early interruption of the hyperthyroidism. Hyperthyroidism undoubtedly influences diabetes unfavorably and vice versa. Careful blood sugar studies and a careful differential diagnosis between glycosuria and actual diabetes must be made lest one conclude that diabetes has been cured by thyroidectomy.

#### IODINE AND THE THYROID

*Historical.* For many centuries it has been known that the ashes of sponges and sea-weed had a beneficial effect upon certain types of goiter. It was, however, not appreciated that the therapeutic effect was due to the iodine content of the ashes. In 1820, Coindet published his successes with iodine in Switzerland. In 1863, Trousseau intending to write a prescription for tincture of digitalis, by mistake prescribed fifteen to twenty minims of tincture of iodine to a patient very ill with Graves' disease. To his very agreeable surprise he noticed after two weeks what we now realize was an iodine remission. He then altered the prescription to one for tincture of digitalis and the patient soon relapsed into her former critical condition. Trousseau, however, was not long deceived and warned against iodine as a therapeutic measure in the treatment of exophthalmic goiter. An enormous and in fact, confusing literature has accumulated since Trousseau's time. In 1896, Baumann demonstrated that the thyroid gland normally contains iodine. Later he and his colleagues showed that iodine given to animals is stored in the thyroid and that when there is a deficiency of iodine in the diet, a compensatory colloid hypertrophy occurs. Kocher, in 1907, while realizing the benefits in endemic colloid goiter treated with iodine, warned against the use of iodine in any and all goiters showing activity for fear of serious consequences. His original warning would seem to be equally apropos today.

Between 1908 and 1911, Marine with Williams and Lenhart demonstrated a definite relationship between the iodine content and the histological structure of the thyroid. They showed that cellular hyperplasia and hypertrophy are due to a deficiency of iodine and that in general the iodine store in the thyroid gland varies directly with the amount of stainable colloid. Kendall, in 1914, isolated the crystalline, active principle of the thyroid and named it thyroxin.

Loevy and Zondek, in 1921, showed that the increased metabolic rate in exophthalmic goiter could be markedly reduced by the administration of potassium iodide. Moreover they observed a striking, though transient, improvement in the clinical symptoms. The thyroid gland has an extraordinary affinity for iodine and the amount that can be stored by any given thyroid varies with the degree of active hyperplasia.

*Iodine in Exophthalmic Goiter.* In 1924, Plummer published his data on the preoperative administration of Lugol's solution to patients with exophthalmic goiter. The results were startling. He found, and it has since been abundantly verified, that when iodine is administered to a patient previously untreated, in the course of ten days to two weeks a marked clinical improvement occurs. The weakness, nervousness and general status are greatly benefited. Moreover, a significant gain in weight of four to eight pounds or more generally follows. Paralleling the marked clinical improvement, the pulse and the basal metabolic rates fall correspondingly. Indeed in some cases the basal metabolic rates may drop to normal levels, and the patient may well wonder why an operation is necessary. Locally, the thyroid gland commonly swells, becomes firm and even hard, and there is an increase in its density due to a rapid accumulation of colloid in the glandular acini. The vascularity diminishes and the thrills and bruits may be greatly lessened and occasionally actually disappear. It is interesting to speculate as to how the profound changes are brought about. The reduced activity may possibly in some manner fail to demand an increased vascularity. Increased tension on the unyielding thyroid capsule occasioned by the accumulation of colloid within the gland may collapse the vascular spaces and actually force the blood out of the gland. The patient may notice an increase in the size of his neck and complain of a sense of fulness, choking or a mild dysphagia.

Concomitant with the macroscopic changes, there are microscopic changes that are equally striking. The papillomatous infolding of the acini composed of tall, columnar cells with large vesicular nuclei and containing limited amounts of colloid show a complete metamorphosis to the so-called resting stage characterized by large spherical or spheroidal acinar spaces lined by low cuboidal or flattened epithelium with small nuclei. Incidentally the mitochondria which are so indicative of cellular activity are diminished in number and size and have a reduced staining affinity.

It is precisely during the resting stage just described that the thyroid activity is greatly reduced and operation can be undertaken with the least possible risk. Unfortunately this quiescent stage is only transient and in several weeks the secretory activity of the thyroid is gradually resumed and eventually actually accelerated. The gland shrinks, the vascularity increases and in four to six weeks after the iodine is discontinued, there may very likely be an exacerbation of the disease. This condition was known even in the days of Kocher who referred to it as "Jod-Basedow"—an exophthalmic goiter accentuated through the use of iodine rather than one showing progressive activity in the normal course of the disease. Similarly in dealing with patients who, having arrived at the stage of remission just mentioned, were for various reasons allowed to continue under iodine medication, we find that after several weeks the condition will show no further improvement. On the contrary, a chronic iodine phase results during which the striking benefits noticed after two weeks of treatment are gradually lost. The feeling of well-being on the part of the patient slowly disappears. The pulse and metabolic rates gradually rise and the patient may gradually feel herself failing. The true picture becomes masked and the continued use of iodine is without benefit to the patient. If surgical operation is attempted, it is fraught with greater danger than during the quiescent resting period. Indeed if operation is attempted, stage procedures might in the interest of safety become imperative. In either of the circumstances just outlined, the favorable opportunity for operative treatment has been missed and the surgeon will find his judgment severely taxed in both instances.

*Iodine and Adenoma.* When dealing with adenomas, we should keep foremost in our minds that we are dealing with benign tumors of epithelial origin. There is no evidence to show that the appearance and growth of adenomas is in any way involved in iodine metabolism. Furthermore, there is no evidence to show that an adenoma of the thyroid was ever made to disappear under iodine treatment. Why then should one ever administer iodine for the cure of an adenoma? True, there are some who say they have never seen any harm done to an adenoma by iodine. Parenthetically, we dare say that there is no evidence to show that iodine ever harmed a lipoma, yet few people would prescribe iodine for a lipoma on the grounds that they never saw any harm come from such treatment. Negative statements regarding the treatment of adenoma with iodine are hardly enlighten-

ing and may actually be harmful because of their implications. There is a difference of opinion as to whether or not iodine may convert a non-toxic adenoma into a toxic one. However, we believe that iodine never permanently benefits an adenoma. Furthermore our experience leads up to believe that iodine may sometimes be a factor in causing a non-toxic adenoma to become toxic.

Cutler and Graham in a limited series of untreated cases of clinically active adenomas found that improvement was rather the rule than the exception following the administration of iodine. Moreover, they reported an appreciable recession of the basal metabolism. We are of the opinion that in dealing with adenomas, remissions in the hyperthyroidism following the use of iodine usually indicate the presence in the thyroid of hyperplastic cellular elements comparable to those in Graves' disease. Our first five to six hundred patients with adenomatous goiter were operated upon before the standardized routine preoperative treatment with iodine was generally in vogue. Our results were quite satisfactory. In fact our records since the advent of iodine medication have been no more satisfactory. We are, therefore, indifferent as to whether we do or do not prescribe iodine preoperatively in all cases of non-toxic adenoma. When we give iodine, we do so principally on the grounds that while a brief preoperative iodination may do some good, it can do no harm unless treatment is prolonged. In the case of undoubted toxic adenoma, we are inclined to agree with Cutler and Graham. Lugol's solution is prescribed for a brief period not to exceed ten days to two weeks following which varying degrees of clinical improvement are occasionally noted.

We believe that the continuous intermittent treatment with iodine of exophthalmic goiter patients over varying periods is fraught with danger<sup>10</sup> and have repeatedly noticed a more satisfactory response of the patient who has never been given iodine as compared to that of the patient who has been treated for some time, possibly intermittently, regardless, too, of the degree or duration of the disease and the dose of iodine. Consequently, we believe that we can predict a striking improvement in the case of the patient who is having iodine for the first time. Conversely, if the patient has had iodine in the past, we can confidently predict a less satisfactory response to further treatment. Some observers believe that failure of improvement under continued treatment with iodine in Graves' disease merely indicates failure to favorably alter the course of the

disease and imply that without iodine, the course would have been more severe. Consequently they continue to prescribe iodine claiming that with time and patience on the part of both physician and patient, the disease will eventually regress. Our experience, and we believe that of most thyroid surgeons, is in disagreement with this view.

When the short intensive preoperative iodination of the patient has not been carried out and she comes to us partially, incompletely or intermittently iodinated, we are confronted with a situation in which the basic expression of the disease is masked. Such a case must be given individual attention. No definite routine seems applicable and satisfactory. Sometimes we interrupt the iodine treatment and sustain the patient with sedative and symptomatic treatment for six to ten weeks to allow the thyroid to eliminate the excess of iodine and to become sensitive again to iodine. Lugol's solution is then given for ten days to two weeks. Operation can then be undertaken under more favorable conditions. In other instances, to conserve what gains might have been made, we continue the use of iodine in increased dosage augmented possibly by several daily intravenous injections of sodium iodide for a period of a week or ten days. If the condition improves appreciably, operation is performed. If no improvement or on the contrary intensification of the clinical symptoms occurs, the iodine is discontinued and operation postponed for six to ten weeks. While the second iodination usually improves the patient, the amelioration of symptoms is usually less striking than following the standardized first period of treatment. A certain number of cases may become refractive to iodine.

Thus far we have been discussing the role of iodine in hyperthyroid states. While our subject matter is that of hyperthyroidism, it might not be unwarranted to mention briefly the only type of goiter in which in our opinion iodine is indicated for therapeutic cure—simple colloid endemic goiter, the inactive type of parenchymatous goiter commonly developing when there is a deficient intake or a faulty metabolism of iodine. It occurs endemically in so-called goiter belts throughout the world. It may be prevented by the prophylactic administration of minute amounts of iodine. Colloid goiter does not produce hyperthyroidism but frequently shows varying degrees of hypothyroidism. Small doses of thyroid extract as well as iodine are then indicated. A caution should be sounded lest overtreatment with iodine stimulate the gland and superimpose a state of hyperthyroidism.



## GENERAL TREATMENT

*Puberty Hyperplasia.* In our discussion of the mild hyperplasias of the puberty type we indicated that they may undergo spontaneous cure. Medical treatment consists principally of mental and physical rest and the administration of tonics and sedatives. A careful routine of eating, sleeping and physical activity should be instituted. A young girl may have to forego her schooling or employment on account of nervousness and emotional instability. Hence the economic loss may be considerable. Since x-rays inhibit hyperplastic tissue, a series of mild x-ray treatments may occasionally be a helpful adjunct to medical treatment. Inordinate doses, however, should be mentioned only to be condemned. Relapses after apparent cures are common and it is not surprising that a goodly number of the milder hyperplasias progress to the more moderate types and that a certain number may eventuate in exophthalmic goiter. Detailed histories indicate that the progression is not too uncommon and may be facilitated by the increasing strain of life as the young girl becomes older and particularly when the responsibilities of marriage and childbearing enter her life. Iodine should not be included in the medical treatment lest it produce an exacerbation or conversion into a more active type of hyperplasia. If medical treatment fails, recourse to operation may become necessary.

*Exophthalmic Goiter.* In dealing with patients presenting exophthalmic goiter, one must always bear in mind their extremely sensitive, high-strung and complex natures. All sources of anxiety, fear and worry should be eliminated. A sympathetic approach on the part of nurses and doctor is necessary to gain the patient's confidence. The routine of life should be carefully controlled—admittedly a difficult task in the case of those who by dint of economic resources are forced to earn their living by jobs that may strain their already overtaxed nervous systems. If the economic status permits, a vacation under a complete change of environment and freedom from responsibility may be of untold benefit. General measures including sedative treatment, an adequate balanced diet stressing carbohydrates and a maintenance of the water balance should be instituted. In brief, the medical management consists of rest—both mental and physical—and general supportive measures. Exophthalmic goiter is a progressive disease and should be treated surgically when frankly expressed. In the early cases, operation is indicated if a period of three to four

months of rest and medical treatment fail to halt the condition. Because they tolerate suspense poorly, most patients once convinced that medical treatment is no longer helpful accept operation graciously. In the highly emotional and fearful, we have found that a brief period of hospitalization in or in close proximity to a ward containing convalescent postoperative cases of hyperthyroidism will work wonders in preparing the prospective patient psychologically and emotionally for the ordeal of operation. When operation is finally agreed upon, Lugol's solution, which during the preliminary symptomatic and medical treatment had been purposely withheld, is given in doses of M X—XV t.i.d. and after ten to fourteen days a striking remission as described under "Iodine and the Thyroid" is customarily obtained. Operation should be undertaken during the period of remission.

*Adenoma.* In dealing with toxic adenomas of the thyroid the problem is comparatively simple. We are dealing with tumors that per se are causing the hyperthyroidism. Surgical removal of all the adenomatous tissue is, therefore, the rational treatment. Prophylactic removal of non-toxic adenomas is advisable to prevent them from becoming toxic, to avoid future pressure effects and to forestall malignant degeneration which occurs in 2 to 4 per cent of cases.

*Hyperthyroidism with Degenerative Effects. The Thyrocardiac.* We have already detailed the severe consequences to the myocardium resulting from continued hyperthyroidism. These may express themselves in a variety of ways and add greatly to the difficulties of the preoperative preparation. The cardiac manifestations may overshadow and mask the hyperthyroidism. The incidence of heart failure is generally higher with toxic adenoma than with Graves' disease. This may be due to the greater chronicity of the toxemia resulting from adenoma as well as preexisting cardiac disease—arteriosclerosis, hypertension or depleted circulatory reserve—incidental to the average greater age of the patients afflicted with adenoma.

The preoperative preparation of the thyrocardiac is extremely important and demands patient and thoughtful consideration. Rest and sedatives are necessary in every case. Rest in bed may be imperative especially when there are evidences of decompensation. Digitalis in adequate dosage is indicated. If edema supervenes, fluids should be restricted to aid in the restoration of competency. In selected cases presenting severe peripheral edema and abdominal ascites, we have

occasionally resorted to intravenous diuretics such as mercupurin or salyrgan in conservative doses. They should, if used at all, be given with extreme caution and are contraindicated when renal function is impaired. Every effort should be made to obtain cardiac compensation since it is ordinarily not wise to undertake thyroidectomy before all evidences of decompensation are overcome. When competency of the circulation has been established, we are prone to wait a few days or longer to see how well competency is maintained or if the heart again becomes incompetent after the fluid intake is increased or the diet is liberalized. When maximum improvement has been obtained and maintained, the intensive preoperative treatment with Lugol's solution is commenced and further striking improvement is usually obtained. Thus if fibrillation has been present, the rate tends to decrease and become regular, the cardiac reserve is strengthened and the general physical condition of the patient is enhanced. It is of course realized that it is not always possible to completely restore the normal rhythm. The period of treatment varies in the individual case from four to seven weeks instead of the ten days to two weeks in uncomplicated case. Obviously two weeks is hardly sufficient time to overcome fibrillation, eliminate edema and build up cardiac reserve. We feel that an occasional fatality may follow a too hasty preoperative preparation. Slow preparation allows the patient to consolidate her gains and renders her a much better surgical risk. It provides the surgeon with a better perspective and a finer prognostic view. It should be realized that in the occasional "desperate risk" patient, who perhaps is suffering from general anasarca, extreme dyspnea and even cyanosis, prolonged preparation may be out of the question. Iodine may have to be given promptly and intensively. It may indeed be the patient's only chance of survival.

#### OPERATIVE TREATMENT

When the maximum clinical improvement has been obtained by preoperative preparation, operation should be undertaken.

*Preoperative Medication.* Amytal grs.  $1\frac{1}{2}$  is given the night before operation. Morphine gr.  $\frac{1}{8}$  is given one hour before the scheduled time of operation and repeated immediately before the patient is sent to the operating room. When using cyclopropane, too much preliminary medication tending to depress respiration is not advisable since cyclopropane is not a respiratory stimulant.

*Anesthesia. Cyclopropane.* From 1919 to October, 1935, nitrous oxide and oxygen with or without ether had become the anesthetic of choice in the Goiter Clinic of the Long Island College Hospital. Since then, cyclopropane<sup>9</sup> has practically supplanted all other forms of inhalation anesthesia in our clinic. It is said that cyclopropane has the potency of chloroform and ether without their irritant qualities, and, excepting in high concentrations, is not measurably harmful to liver, kidneys or heart. A high potency may produce spasm of the larynx. The usual laryngeal reflexes are, therefore, not present to warn the anesthetist. Consequently, hasty induction must be avoided. Unlike nitrous oxide and ethylene which increase the rate and volume of respiration and even produce depression from oxygen deficiency, cyclopropane causes comparatively little if any change in the rate and volume of breathing unless excessive concentrations are used. The large amounts of oxygen given with the gas prevent cyanosis and the blood, consequently, should always maintain a bright red color.

Only a few minutes are required to produce surgical anesthesia in the average patient with hyperthyroidism. Unusually nervous patients, especially those with high metabolic rates require a longer induction and greater concentrations of the gas. An initial potency of 5 to 10 per cent of cyclopropane with 90 to 95 per cent of oxygen is generally satisfactory and the operation can usually be continued with the lower limits of concentration. There is no excitement period and the various stages from induction to deep narcosis are merged rapidly. However, the patient is at all times protected by the large concentrations of oxygen. Unlike nitrous oxide and ether, cyclopropane does not produce choking, burning or strangling. It is not unpleasant. Recovery is quick and the patient can usually coöperate promptly. Postoperative nausea and vomiting are less prolonged than with other inhalation anesthetics, notably ether.

In exophthalmic goiter with greatly elevated metabolism, the patient's demand for oxygen is frequently so great that we have in the past had difficulty when employing nitrous oxide in preventing anoxemia. Ether frequently had to be supplemented to obtain relaxation. Venous congestion during the operation was at times disturbing, postoperative nausea and vomiting were increased, the postoperative conscious responses were delayed and acidosis and acetonuria were more frequently encountered.

Inasmuch as a large number of goitrous patients have varying degrees of cardiac damage, a powerful anesthetic like cyclopropane which can be administered without producing anoxemia has distinct advantages. Most thyrocardiac patients require more than ordinary amounts of oxygen. When cyclopropane is used, the high oxygen ratios tend to protect the overburdened myocardium against the strain of operation.

In removing large adenomatous goiters, particularly those that have caused tracheal narrowing or compression, cyclopropane is especially helpful. The tracheal reflexes are quickly abolished and sufficient oxygen can usually be supplied to prevent respiratory distress, venous congestion and asphyxia, even with passive breathing. The quick abolition of the throat reflexes by cyclopropane is of great value when recourse to airways becomes necessary. Helium is a valuable adjunct in many such cases. It has been demonstrated experimentally that cyclopropane in concentrations sufficient to produce surgical anesthesia does not seriously depress liver and renal function. It is, therefore, well suited for cases of prolonged hyperthyroidism with hepatic and renal damage.

*Avertin.* In cases of extreme toxicity in which emotionalism, great anxiety, fears and phobias are the outstanding symptoms, we have given basal avertin anesthesia to great advantage as a preliminary to cyclopropane. Following doses of from 50 to 80 mg. per kilo of body weight, the patient comes to the operating room greatly relaxed both mentally and physically—in a kind of twilight sleep. The induction and the operative course are consequently greatly facilitated.

*Local Anesthesia—Novocaine.* Occasionally when dealing with large adenomatous goiters we have used local infiltration with  $\frac{1}{2}$  to 1 per cent novocaine. If compression of the trachea threatens, the operator with the patient's coöperation can usually manipulate the tumor mass so as to avoid strangulation. The laryngeal reflexes are maintained. The fear and trepidation of the patient is counteracted by indulging him in light and carefree conversation. Local anesthesia may be enhanced by repeated small hypodermic doses of morphine during the course of operation or supplemented by cyclopropane, or other general anesthetic.

*Intratracheal Anesthesia.* In certain cases of large adenomatous goiters with tracheal compression, especially if they are largely intrathoracic, it is difficult even with cyclopropane to supply enough

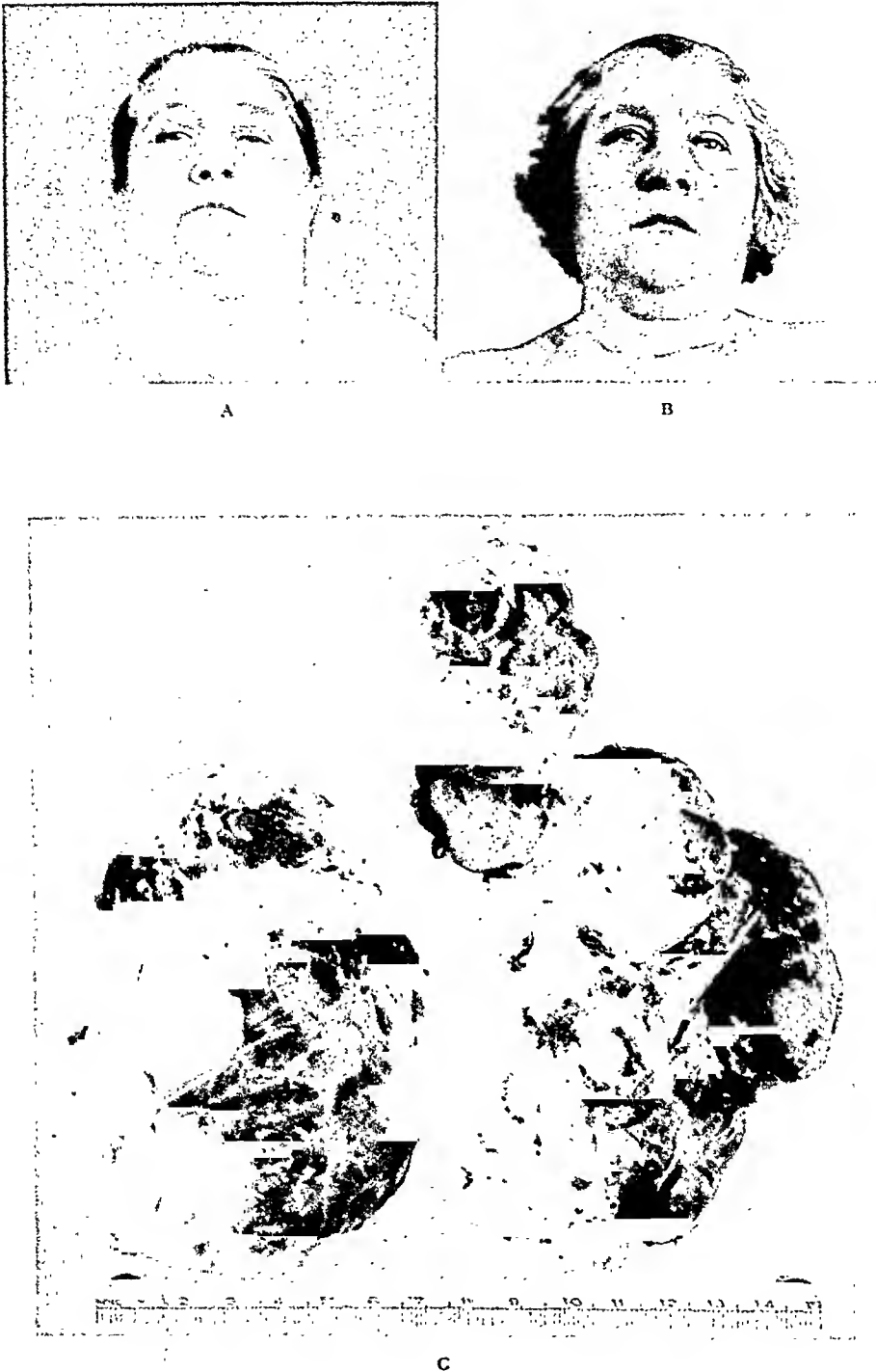


FIG. 7. R. G., age 57. A, huge bilateral adenomatous goiter which required intratracheal anesthesia. B, postoperative photo taken three weeks following operation. C, photo of gross specimen.

oxygen. The delivery of the mass from the thorax may further constrict the already compromised trachea. In the exceptional case, the introduction of an intratracheal catheter as a preliminary to operation will solve the difficulty. (Figs. 7A, B and C.)

#### TECHNIQUE OF OPERATION

*Exophthalmic Goiter.* The operation of thyroidectomy has in a large measure become well standardized. Obviously, however, in view of the marked variation in the size, position and clinical activity of a goiter one cannot follow a rigid procedure. It is our purpose, therefore, to outline the principal steps in our routine and to refer the reader to standard textbooks and monographs for anatomical and other details.

Because the vast majority of patients are women, the postoperative scar becomes a matter of compelling interest. The collar incision is universally employed. It should follow and parallel the folds of the skin at a sufficiently high level to place the ultimate scar at the best cosmetic level. The upper and lower flaps are thoroughly mobilized. Bleeding is minimal if the exact line of cleavage is maintained. A self-retaining retractor is used to spread the upper and lower flaps. The ribbon muscles are freed from the thyroid by sharp dissection and separated from the gland by a retractor held by an assistant. When the gland is inordinately large or has an unusually high superior pole, the prethyroid muscles may be divided to facilitate exposure. However, we find no need for routine division and when resorted to, make the division at a high level to conserve the innervation and retain the normal muscle tone.

The right lobe and isthmus are separated from the left lobe by careful dissection over the midline. When a prominent isthmus is present or the trachea is deeply situated, separation is greatly facilitated by a puncture wound of the knife in the suspensory ligament through which a curved Kocher clamp is carefully guided along the tracheal fascia to the lower limits of the juncture of the right and left lobe. By a careful, light spreading of the clamp, a practically bloodless groove is obtained and separation of the overlying isthmus from the left lobe is easily accomplished. The lobe is further freed by careful dissection medially along the trachea; the handle of the scalpel is used to exert firm but gently pressure to gain further mobilization. Next, attention is directed to the upper pole which on account of its fixation, may be difficult to free. However, if the sus-

pensory ligament is severed, a relatively free space may be developed between the medial aspects of the upper pole and the cricoid and laryngeal cartilages. By carefully holding a Kelly clamp in close proximity to the thyroid capsule and gently spreading it in the axis of the tracheolaryngeal groove, some fibrofatty supporting tissue is easily severed and a bloodless separation is obtained. The superior pole and superior thyroid artery are lifted to the side and well away from their proximity to the superior laryngeal nerve which among other things supplies sensory filaments to the epiglottis, base of tongue and the mucous membrane of the larynx as well as motor twigs to the cricothyroid and, according to some authors, to the interarytenoids which are concerned in the approximation of the posterior portion of the vocal cords. The upper pole is mobilized posterolaterally by gently freeing any muscle or fascial attachments with the handle of the knife or a dissector of the type of the Küttner clamp. The superior thyroid artery is clamped, divided and separated from the gland. If the preceding steps have been adequately performed, the pole can be easily lifted and rolled upward and inward. Forceful traction against the trachea and larynx should be avoided. The artery can now be ligated without fear of injury to the superior laryngeal nerve. Voice changes and irritative postoperative coughing formerly attributed solely to recurrent nerve injury will be further reduced by protecting the superior laryngeal nerve.

The lower pole is gently lifted and the lobe is rotated and gently freed from any posterolateral attachments. Dividing and transfixing of the inferior thyroid and capsular veins further facilitate mobilization. As the gland is elevated and separated from any supporting fibrofatty posteriorly, great care must be exercised to avoid the parathyroids. Unless adequate mobilization is obtained, the operator has no real way of estimating the amount of tissue to remove. Therefore, before commencing the resection he should make certain that both poles are elevated and that he has discovered any posterior projections or extensions of tissue. Having decided upon the amount of tissue to remove, the operator may commence either laterally or medially, placing a row of guide and hemostatic clamps along the capsules at a level above which he decides to commence the resection. The medial row should be well above the tracheo-esophageal groove particularly in the vicinity of the tracheolaryngeal angle where the superior parathyroid body is especially prone to be injured. The outer row must be placed lateral to the entrance of the inferior



thyroid artery and run in a slightly upward curve toward the beginning of the anterolateral branch of the superior thyroid artery. The exact level of the row of clamps in the individual case is determined by the operator's estimate of the amount of tissue he wishes to remove. When less radical resections are desired, the clamps are placed correspondingly higher. By properly placing the guide clamps the posterior "danger zone" containing the parathyroids and the recurrent nerve is avoided. Therefore, tetany and recurrent nerve injuries should virtually never occur. Resection is carried out by wedge removal, the apex of the wedge being directed toward the posterior capsule. Bleeding points are clamped as they are encountered. We have not found it necessary to ligate the inferior artery as a preliminary to resection and are inclined to believe that routine ligation of this artery might increase the tendency to parathyroid tetany since the sole blood supply of the parathyroids comes directly from the inferior thyroid arteries.

The lateral and medial capsules are approximated by a running fine catgut suture and a series of interrupted fine silk sutures. Unless a stage procedure has been decided upon, the left lobe is exposed and resected. The amount of tissue to be removed is estimated to some extent on the size of the right remnant. The operative field is closely examined for any minor bleeding and when a dry field has been obtained, closure is undertaken. The ribbon muscles are united over the midline by small interrupted silk or fine catgut sutures. Their lower limits are not approximated so as to allow any subsequent collection of blood and serum in the depths to come to the surface. A row of fine interrupted silk sutures about 1 cm. apart are used to unite the subcutaneous flaps. Finally, a series of fine silk sutures are employed to coapt the skin.

Should the wound be drained after an operation for goiter? When dealing with small firm glands in which a dry field is obtained with relative ease, drainage is not necessary. However, when dealing with large, soft and vascular glands requiring much suturing to control hemostasis, a small tissue or cigaret drain is inserted under the upper flap between two skin sutures and removed in the evening of the day of the operation.

*Adenomas of the Thyroid.* In dealing with nodular or adenomatous goiter, the problem resolves itself into removing all adenomatous nodules and leaving all the healthy tissue in order to maintain normal thyroid function. Most of the principles and procedures already de-

scribed are applicable. However, on account of the frequent distortion of the surgical anatomy as regards the thyroid arteries, parathyroids, laryngeal nerves and the trachea, the customary land-



FIG. 8. M. O., age 50. A, x-ray film showing large intrathoracic adenoma with pressure effects. B, photo taken three weeks following sternotomy for removal of intrathoracic goiter.

marks that guide the operator may be greatly obscured and unusual precautions may be necessary to avoid operative and postoperative complications. Moreover, transverse division of the prethyroid muscles will have to be practiced with greater frequency than in dealing with hyperplastic goiters. Ample mobility must be obtained lest one or more nodules escape detection and in later years cause recurrent hyperthyroidism. A row of clamps is placed along the medial and lateral capsules at a level well above the posterior "danger zone." Since adenomas have discrete capsules, a plane of cleavage

can usually be developed by making an incision to the depth of the nodule and shelling it out from the surrounding thyroid tissue. Where a number of nodules are present, they should be enucleated seriatim.



FIG. 8. For descriptive legend see opposite page.

In dealing with multiple small nodules particularly when the intervening thyroid tissue is hyperplastic, resection-enucleation is practiced. To facilitate resection-enucleation, the anterior surface of the lobe which is usually thinned out and frequently fibrous or degenerated, may be excised. By this unroofing process, access to the underlying pathology is obtained and an intracapsular wedging procedure is carried out as radically as necessary to remove all adenomatous nodules and the bulk of the hyperplastic tissue. The most healthy looking tissue will generally be found along the posterior capsule about the upper pole and sufficient tissue can nearly always be salvaged to prevent postoperative hypofunction.

In dealing with substernal goiter, complete mobility and luxation are of paramount importance. To gain ample mobility, the prethyroid muscles will almost certainly need transverse division. It is important to free the mass along the trachea. All division of tissue

should be made after careful double clamping. The upper pole must be thoroughly mobilized. The suspensory ligament and any fascial attachments are carefully freed and the superior thyroid artery is ligated at a high level. It should be remembered that in the process of descent, an intrathoracic goiter carries downward with it the thyroid arteries and superior, middle and inferior veins. Thus by double clamping and dividing the main blood vessel trunks along the capsule, the circulation can be completely controlled from above. The tumor mass is finally freed and delivered by gentle manipulation and extracapsular dissection along a well-defined plane of cleavage. If the preceding maneuvers have been carefully carried out, it is surprising how readily even large masses can be guided upward into the operative field. When central softening or cystic degeneration has occurred, puncture of the capsule may facilitate delivery. We have had recourse to sternotomy only once and have had to use intratracheal anesthesia in rare instances. (Fig. 8A and B.)

*Stage Operations.* One of the most important principles guiding the thyroid surgeon is that the operative procedure should not go beyond the limits of the patient's tolerance. Fortunately a single complete operation that might prove fatal can generally be carried out successfully in successive stages; the extent of the surgical procedure and the number of stages in each instance depend upon the individual case. Whether one or two preliminary ligations should precede a single lobectomy followed later by a second lobectomy will depend upon the condition of the patient when first seen before the real status of the hyperthyroidism is masked by suppurative treatment—rest, fluids and cardiac support. The surgeon's judgment will frequently be severely taxed. There is unfortunately no substitute for experience, nor can any rigid rules be given. However, when in doubt, one should not hesitate to do stage operations for it is obviously wiser to operate two or even three times safely than to have a complete operation and a dead patient.

*Preoperative Criteria of Operability.* In attacking the problem of operability, experience has shown that certain preoperative factors indicate the wisdom of stage procedures in safeguarding mortality. Among these are inordinate weight loss, severe asthenia, prolonged severe hyperthyroidism especially in the presence of marked cardiac damage, the presence of chronic valvular disease, inordinately high metabolic rates especially when maintained in spite of adequate preoperative iodination, vomiting and diarrhea and unusual mental

states bordering on psychosis. The indiscriminate and improper use of iodine may mask the true state of the hyperthyroidism and lead to the necessity for stage procedures. While the correct preoperative use of iodine has, excepting in very unusual instances, obviated preliminary ligations, it has by no means excluded the necessity for stage operations. In dealing with extreme degrees of hyperthyroidism, a single ligation may be done to test the operability. If the patient's reaction is favorable, the operation may be undertaken following the average routine. If the reaction is severe, caution and stage procedures would seem to be in order. (Fig. 9A, B, C and D.)

*Operative Criteria.* In our own experience it has become abundantly evident that postoperative crisis with which it is difficult to cope remains the principal cause of death. Even though the hyperthyroidism is partially controlled by careful preparation, the basic hypersensitivity of the patient to operative assault may still be present to a marked degree. It is revealed in the emotional reactions of the patient during the immediate preoperative period and just before anesthesia, as well as during the reactions produced by unavoidable trauma associated with the operation. The preoperative manifestations of tachycardia, nervousness, flushing, tremor and throbbing are secondary to the emotional factors of fear and anxiety. Likewise, the operative reactions of increased blood pressure and pulse rate, leukocytosis, increased blood sugar and a rise in temperature are secondary to trauma and other deleterious factors of the operation.

In an attempt to evaluate the operative reactions, it became apparent to us (Goetsch and Ritzmann),<sup>7</sup> that they showed striking resemblances to the reactions produced by the injection of small amounts of adrenalin in patients suffering from hyperthyroidism. Furthermore, the patients that were particularly sensitive to adrenalin as determined by the adrenalin test (Goetsch)<sup>11</sup> invariably showed proportionately sharp postoperative reactions. Even crisis seemed to be an exaggeration of the responses which can be produced by adrenalin in the hyperthyroid patient. The differences were solely of degree rather than type and character. The striking parallelism between the adrenalin and operative reactions suggested strongly that the latter are due to a hypersecretion of adrenalin produced by the factors inherent in the operation—emotion, fear, operative trauma and anesthesia—in stimulating the suprarenal glands. The sympathetic nervous system already rendered hypersensitive by the

hyperthyroidism would appear to be further stimulated by the additional adrenalin. It was moreover found that the postoperative hyperthyroidism is proportional to the degree of the operative reac-

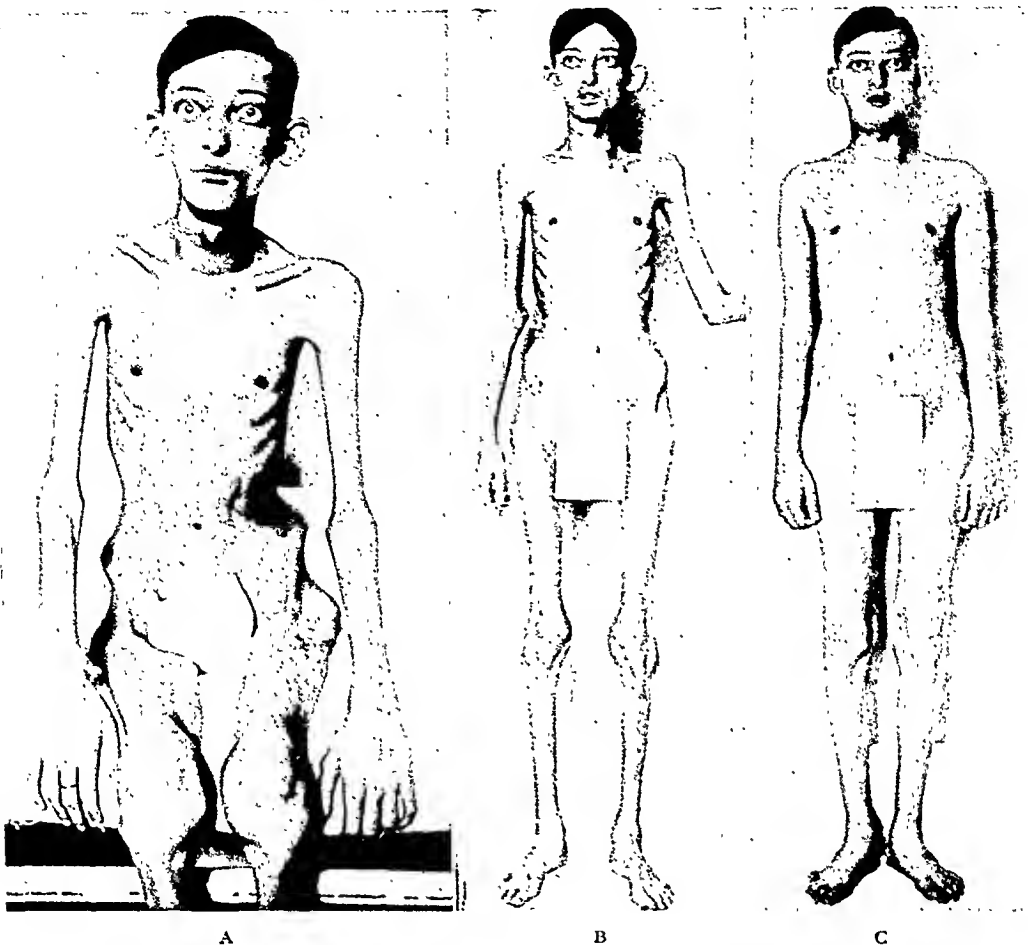


FIG. 9. H. K. A, age 15. Photo taken 4/9/27. Severe exophthalmic goiter. Patient in extremis from marked emaciation and debilitation. B, age 16. Photo taken 4/19/27 following two previous superior ligations in stages. C, age 16. Photo taken 6/6/27. Note further marked physical improvement following previous superior ligations. D, age 26. Photo taken in October, 1938, ten years following two lobectomies in stages after two individual ligations had been done previously. It required four stage operations to obtain this result.

tions. Thus an early sharp rise in the pulse rate, blood pressure, pulse pressure and respirations should warn the surgeon of an unusual sensitivity and a threatened severe postoperative reaction especially if these factors rise progressively and are sustained. The desirability of restricting the operation and adopting a stage procedure become apparent. Reduced to clinical practicality we would say that given a case of hyperthyroidism that on the basis of preoperative criteria

presents a problem in operability, we have a rather recent and helpful criterion of the patient's tolerance for operation in an evaluation of the operative reactions. If by the time the first lobe has been re-

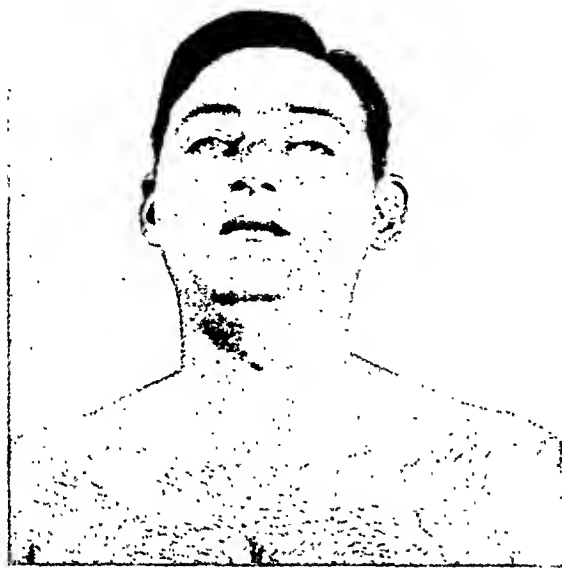


FIG. 9. For descriptive legend see opposite page.

moved, the blood pressure and pulse rate have tended to rise progressively, a first stage single lobectomy had best be done in the interest of safety. In this connection, the behavior of the blood pressure has come to mean more to us than that of the pulse. We believe that careful study and interpretation of the operative reactions may aid in reducing the incidence of severe postoperative hyperthyroid reactions including crisis.<sup>12</sup> (Figs. 10 and 11.)

*Amount of Tissue to Be Removed.* One of the most important problems in the surgery of goiter with hyperthyroidism is the estimation of the amount of tissue to be removed. Once again no infallible rules can be laid down. In general the younger the patient and the more recent the hyperthyroidism the more radical the resection must be to prevent recurrent hyperplasia. In older patients, the glands tend toward diminished functional activity and less radical resections are indicated to preserve normal physiological thyroid activity. Obviously, when too much tissue is removed an undesirable state of hypothyroidism and even myxedema may result and, conversely, if

too little tissue is removed a persistent postoperative hyperthyroidism may follow. In the individual case an estimate is not based on any one criterion such as the basal metabolic rate. Rather one must

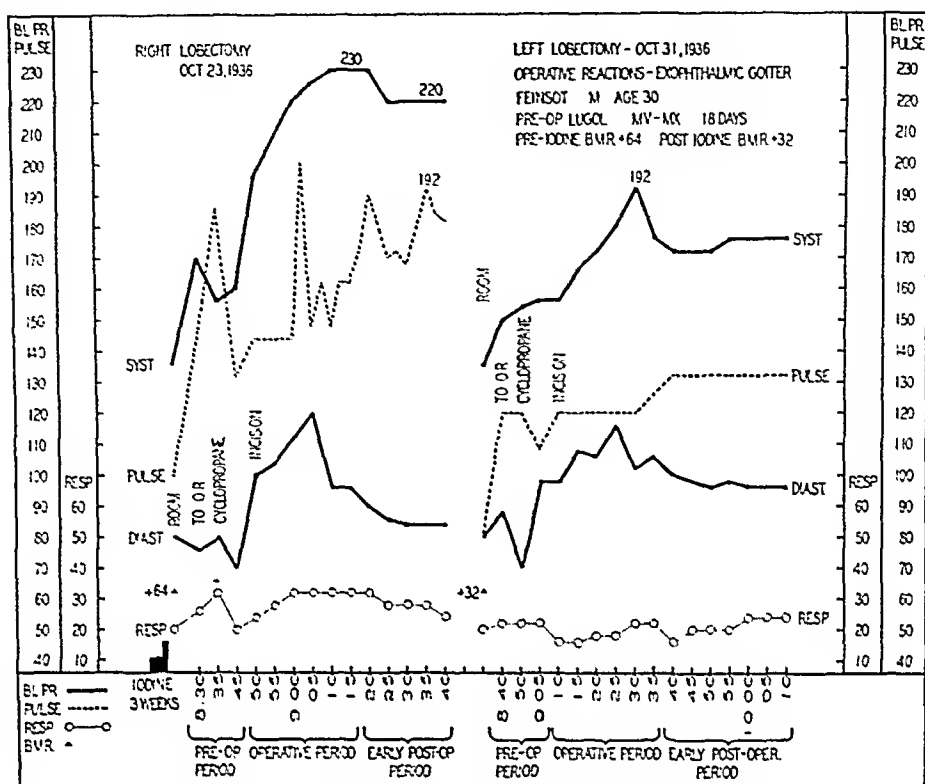


FIG. 10. Severe operative reaction during first stage right lobectomy for marked hyperthyroidism due to Graves' disease, indicating need of restricting the operation. Note continued climb in pulse and blood pressure. Compare with less severe reaction during second stage left lobectomy.

first of all view and interpret the composite picture—the clinical activity as expressed by tremor, tachycardia, loss of weight, the presence or absence of mental deterioration and the basal metabolic rate. Secondly, the individual's reaction to preoperative iodine medication is important. In those patients that react favorably to preoperative treatment with iodine, there will be a marked fall in the basal metabolic rate, an appreciable gain in weight, a diminution in the pulse rate and a general improvement in the nervous symptoms. At operation the glands of such patients will invariably show an abundant content of colloid. They will be firm, pale and relatively avascular. Sections are characteristically translucent. During the stage of iodine involution, the gland is relatively inactive and its bulk is mostly inert colloid. Obviously in dealing with such glands the



reduction should not be too radical. However, when the clinical response to iodine is limited and the gland at operation is still very vascular and fleshy in appearance indicating lack of complete involu-

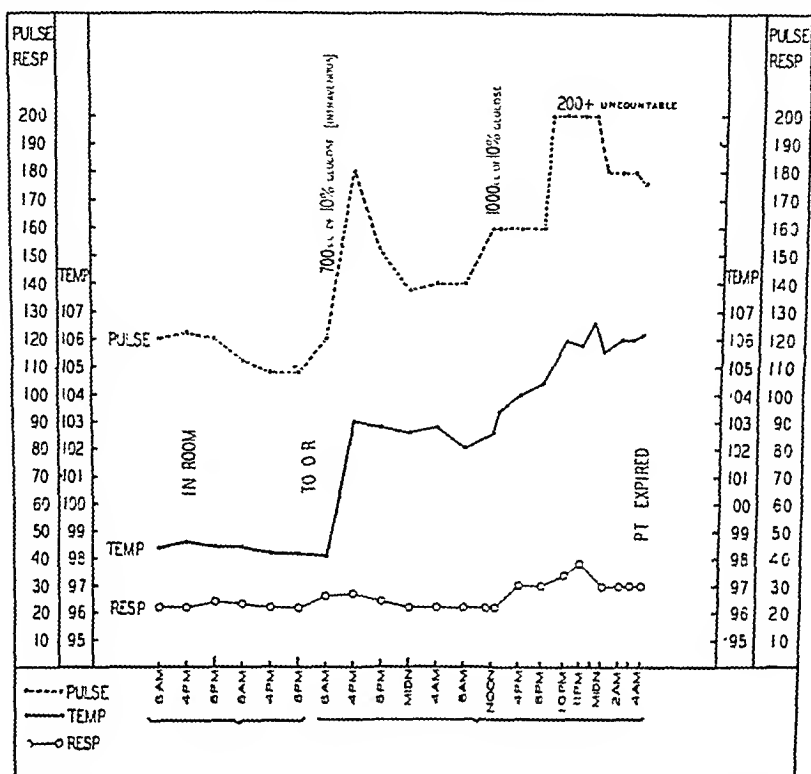


FIG. 11. Severe postoperative reaction ending in death from crises less than forty-eight hours following second stage left lobectomy for severe exophthalmic goiter in a young girl, aged 19. Note the abrupt climb in both temperature and pulse rates. Just before exodus, the pulse was uncountable and the temperature 106°F.

tion, a relatively more radical reduction must be made. In cases presenting marked cardiac damage, radical reductions are in order even at the expense of producing underfunction so as to relieve the overloaded heart.

#### POSTOPERATIVE COURSE AND TREATMENT

In the average case in which the hyperthyroidism has not been too prolonged or too damaging to the cardiac and physical status of the patient and in which no special operative difficulties have occurred, the patient may confidently be returned to his room and require only the customary, routine symptomatic treatment. If

cyclopropane has been used consciousness is quickly established. There is little danger of inspiring vomitus and the patient may soon be placed in a low Fowler position and later shifted to such positions



FIG. 12. A. C., age 32. Recurrent hyperplasia in pyramidal lobe one year following subtotal resection for exophthalmic goiter.

as are most comfortable. Small repeated doses of morphine are used during the first forty-eight hours to control discomfort and pain. Later bromides and phenobarbital derivatives are usually adequate. Persistent vomiting and dehydration are best controlled by intravenous and rectal administration of glucose solutions according to the rationale elaborated above under the heading of "Acidosis following Operation." Fluids are given by mouth as soon as tolerated and a small bland breakfast is frequently possible and often acceptable on the morning after operation. High caloric foods especially carbohydrates should be encouraged and are usually well tolerated. The peak of the postoperative febrile and pulse reactions occurs in about thirty-six hours and should be controlled with ice caps over the precordium and the head and cold sponging. Heart stimulants are rarely needed. However, during recovery an occasional case may

show a fall in blood pressure and cyanosis requiring caffeine, strychnine or other stimulants. Arrhythmias, fibrillation and broken compensation require digitalis and similar medication. The rapid pulse rate is unaffected by digitalis and usually drops spontaneously after the postoperative febrile reaction has spent itself. The skin sutures are removed in forty-eight hours so as to prevent unsightly punctate scarring of the suture holes. During the first twenty-four to forty-eight hours, the house surgeon and nurses should be on guard for complications such as crisis, hemorrhage, respiratory distress, pulmonary edema and tetany.

*Crisis.* The characteristics of crisis have already been detailed. Early recognition and treatment of this grave complication are imperative. Since crisis may occur with startling suddenness or appear gradually with definite premonitory symptoms such as increased excitability, loss of emotional control bordering on delirium, increasing hyperpyrexia and an alarming rise in the pulse rate, the house surgeon and the nursing staff should be trained to suspect crisis. The extreme restlessness may require unusual measures. Heavy sedation—morphine and other hypnotics and sedatives—may have to be administered liberally. The hyperpyrexia should be combatted with ice caps over the precordium, head and body and by repeated sponging with ice water. Because of the rapid consumption of glycogen in crisis, the glycogen reserve should be fortified by frequent intravenous injections of glucose solutions. The treatment should be aimed at sustaining the heart until the critical reaction has spent itself since death in crisis is invariably due to secondary cardiac failure.

*Hemorrhage.* Hemorrhage may be severe if each successive step in the operation has not been controlled before proceeding with the next. Factors that are important are (1) adequate exposure, (2) developing and adhering to the normal planes of cleavage, (3) early clamping, division and ligation of the lateral and inferior veins to prevent tearing and retraction, (4) individual ligation of all focal bleeding points, (5) the avoidance of mass ligations and (6) the insistence on a dry field before closing. With the preceding precautions, serious postoperative hemorrhage should be rare. When bleeding does occur, it happens usually during the first twelve to twenty-four postoperative hours. It makes its presence known by a gradual, progressive tenseness of the skin flaps and a gradual increasing respiratory distress. Early reflex coughing increasing to dyspnea and

eventual stridor may follow in rapid succession. No time should be lost in prompt exploration of the operative field and control by suture ligatures of the bleeding points. Incidentally, early interference may prevent the necessity for emergency tracheotomy. In the event that tracheotomy becomes necessary, it should be done as deliberately as circumstances permit and at a low level. If done at a high level in proximity to the cricoid, tracheal stenosis may result since the trachea is narrowest at this point.

*Injury to the Recurrent Nerves.* Formerly recurrent nerve paralysis was cited as among the most frequent and serious complications in goiter surgery. However, the present day improved technique has reduced serious injury to almost nil and relegated slight injury causing transient paresis and mild <sup>hoarseness</sup> ~~hoarseness~~ to relative infrequency. Adequate mobilization, light manipulation, expeditious delivery of the gland, a wholesome regard for anatomical landmarks, the avoidance of roughness and bleeding along the posterior "danger zone" will do much to prevent nerve injury. <sup>Exercised</sup> ~~Exercised~~ especially posterolaterally where the nerve is in close proximity to the inferior thyroid artery. A common notion is that the nerve is in greatest danger in the vicinity of the lower pole. However, the most vulnerable point is undoubtedly along the lateral deeper aspects of the cricoid cartilage in relationship to the cricopharyngeal muscle. Care should be exercised in this area lest the guide clamps be placed too low. Moreover, deep, massive suturing to control bleeding which at the cricopharyngeal angle may at times add to the operative difficulties, should be avoided.

*Pulmonary Complications.* Refinements in the administration of anesthetics, improvements in surgical technique and postoperative management have greatly reduced the incidence of pulmonary complications. Notably the avoidance of recurrent nerve injury and the rapid recovery from cyclopropane have greatly minimized the dangers of bronchitis and aspiration pneumonia. Further factors in prophylaxis have been the general recognition for postponing operation after recent respiratory infections and for thoroughness in the preparation of the thyrocardiac for operation.

*Tetany.* Tetany is a condition of increased irritability of neuromuscular control due to depletion of the calcium level in the blood. Postoperative tetany usually develops within eighteen to forty-eight hours. It is seen less frequently today than in the early era of thyroid surgery. Tetany may occur after removal or bruising of the para-

thyroid glands or following injury to their blood supply. In mild cases, certain prodromal symptoms may indicate an approaching tetany. Headache, a feeling of weakness, pain and stiffness in the muscles of the arms and legs, girdle sensations about the chest and mild muscular twitchings may precede a major attack. One of the earliest signs is that of Chvostek—a twitching of the facial muscles when tapping over the course of the facial nerve. Other early signs are a circumoral pallor and nervous excitement and apprehension occasionally bordering on hysteria. In severe tetany a characteristic sign is carpopedal spasm—a flexion of the fingers at the metacarpophalangeal joints with adduction of the thumb, and turning inward of the foot at the ankle joint with adduction of the great toe. Muscle cramps are common and the voluntary muscles may undergo clonic or tonic convulsions. When the glottis is involved, breathing may become labored and noisy. Severe cyanosis and cessation of respiration sometimes occur as a result of paresis of the intercostal muscles and diaphragm. Severe generalized convulsions may lead to sudden death. The severity of the symptoms parallels the fall of the blood calcium which normally averages 10 mg. per cent. Ordinarily a level of 7 mg. per cent or less produces symptoms. The prognosis depends upon the extent of the damage to the parathyroids. Complete removal of all four parathyroids is of course incompatible with life. When the parathyroids have been extensively traumatized or their delicate nutrient vessels have been thrombosed, they act as glandular transplants and treatment should be continued until their circulation has become reestablished and normal secretory activity has returned.

In mild transient cases, a diet liberal in milk and cheese, augmented by calcium salts by mouth or intravenously and vitamin D is generally sufficient to tide the patient over. In severe cases, periodic parathormone injections may be required. The type and extent of treatment should be controlled by frequent blood-calcium determinations.

In our experience, tetany has occurred only sporadically and for the most part disappeared with routine treatment usually before the patient's discharge from the hospital. In recent years A. T. 10 has supplanted parathormone in protracted cases. However, in our clinic we have not found it necessary to resort to this potent drug. We attribute our low incidence of tetany to: (1) The fact that we do not practice ligation of the inferior thyroid arteries. (2) Meticulous care in avoiding deep suture ligatures when controlling bleeding in the

tracheolaryngeal angle. (3) Avoidance of the posterior danger area of Crotti.

#### RECURRENCES

*Adenoma.* Continued and recurrent hyperthyroidism following operation for adenoma undoubtedly result from the failure to recognize and remove all the nodules particularly when dealing with the younger patients. If it were possible in all cases to remove all the adenomatous tissue and leave all the normal tissue, recurrences would practically be reduced to nil.

*Hyperplasia.* In general it is held that recurrences following bilateral resections are due principally to failure to remove adequate amounts of hyperplastic tissue. While this is generally true, it is by no means invariably so. The problem cannot be reduced to formula. Every case must be judged upon its own peculiar merits and in the light of surgical experience. However, when the surgeon has weighed the various criteria—the duration and severity of the clinical picture, the behavior of the basal metabolic rate before and after iodine medication, the character and consistency of the gland—he may do a radical resection comparable to that employed with success in similar cases only to find a possible persisting, mild hyperthyroidism which in several months or years may eventuate in a return of the original clinical picture possibly even in exaggerated form. Moreover, he may be annoyed to find that the original remnants have hyperplased to such a degree that the recurrent goiter is actually larger than the original.

It is important that no detached remnants of upper pole be allowed to remain in proximity to the superior thyroid artery lest they act subsequently as foci for further hyperplasia and growth. Likewise, the resection of a pyramidal lobe, even though diminutive, is important. An appreciable number of recurrences have been traced to this source. When dealing with certain cases of fulminating hyperplasia that show little or no iodine resolution, we occasionally deliberately court a transient postoperative hypothyroidism particularly in the younger age groups. (Fig. 12.)

Inasmuch as the etiological factors of goiter are very complex and doubtless multiple, it is probable that many recurrences are based on the original cause or “urge” which, while temporarily subdued by thyroidectomy, may still be lying dormant. Thus to be completely effectual and curative, thyroidectomy besides reducing the thyroid gland should break the chain of causative factors—adrenal, thyroid,

pituitary and sympathetic nervous system. In a certain number of cases, this cycle apparently is not broken and produces recurrences.

#### MORTALITY IN GOITER OPERATIONS

In the ten-year period, 1919 to 1929 inclusive, 1755 operations were performed upon 1553 patients with hyperthyroidism at the Long Island College Hospital.<sup>13</sup> There were twenty-two fatalities—an operative mortality of 1.2 per cent.

In the ten-year period, 1929 to 1939 inclusive, 3426 operations were performed upon 3347 patients. There were thirty fatalities—an operative mortality of .86+ per cent which compares favorably with the 1.2 per cent mortality for the first ten years.

Combining these results, we find that in the twenty-year period, 1919 to 1939 inclusive, there were fifty-two deaths following 5181 operations upon 4900 patients with hyperthyroidism in the Goiter Clinic of the Long Island College Hospital—an operative mortality of .98+ per cent. Of these deaths twenty-eight were in instances of exophthalmic goiter, twenty-two in adenoma and two in carcinoma.

Causes of Death (1919 to 1939 Inclusive)	Fatalities
Postoperative hyperthyroidism (crisis) and secondary cardiac failure..	19
Primary cardiac failure.....	12
Embolism.....	6
Pneumonia.....	5
Coronary disease, ventricular fibrillation.....	3
Infection, sepsis, septicemia.....	3
Respiratory failure.....	2
Intravenous injection (accident).....	1
Tetany.....	1
	—
	52

Postoperative crisis still remains the greatest factor in mortality. It accounted for nineteen deaths in our series. Stage procedures may lessen the likelihood of crisis but they by no means entirely eliminate the danger. We have had fatalities following a single ligation and following second and even third-stage procedures. Several cases of fatal crisis followed operation in elderly people for the removal of large, relatively non-toxic adenomas with little or no increase in the basal metabolic rate. Crisis seems thus not to be limited to active hyperplasias with increased metabolism.

Primary heart failure was responsible for twelve deaths. These patients entered the hospital for the most part through the Out-Patient Department and had been suffering for many years from chronic hyperthyroidism with degenerative effects—myocardial in-

sufficiency, decompensation, hypertension, diabetes and other conditions of bad prognostic significance. They were largely desperate risks.

Embolism caused six fatalities. The patients were predisposed by chronic endocarditis, arteriosclerosis, myocardial insufficiency and senility and were, therefore, known to have guarded prognoses.

Pneumonia accounted for five fatalities in rather bad risk patients, yielding in a series of 5181 operations a percentage of only .09+ per cent.

Coronary disease and ventricular fibrillation accounted for three sudden deaths in patients predisposed by serious damage to their cardiovascular systems—chronic fibrillation, cardiac hypertrophy and arteriosclerosis.

Sepsis, respiratory failure, tetany and an accident connected with a postoperative intravenous injection of glucose accounted for the remaining six fatalities.

It is not within the scope of this report to review in great detail the various factors leading to increased mortality. However, irrespective of certain conditions inherent in the individual patient and over which we have only limited control, we believe that the abuse of iodine in the so-called medical treatment strongly predisposes to increased mortality and that we can and should control this factor. When it is more generally recognized that iodine has no place in the medical treatment of hyperthyroidism, we believe that mortality statistics will be further reduced. Other surgeons have likewise emphasized this matter.<sup>14</sup> Twenty-four of fifty-two fatal cases in our series were known to have had indiscriminate treatment with iodine. These included practically all of those dying in crisis. In conclusion, we are of the opinion that if iodine therapy were limited to the standardized preoperative preparation of the hyperthyroid patient, the incidence of dreaded crisis could be reduced to practically nil.

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